SCIENTIFIC AMERICAN SUPPLEMENT. No. 1108

Scientific American, established 1845.
Scientific American Supplement. Vol. XLIII. No. 1108.

NEW YORK, MARCH 27, 1897.

Scientific American Supplement. $5 a year.
Scientific American and Supplement. $7 a year.

THE COKE INDUSTRY.

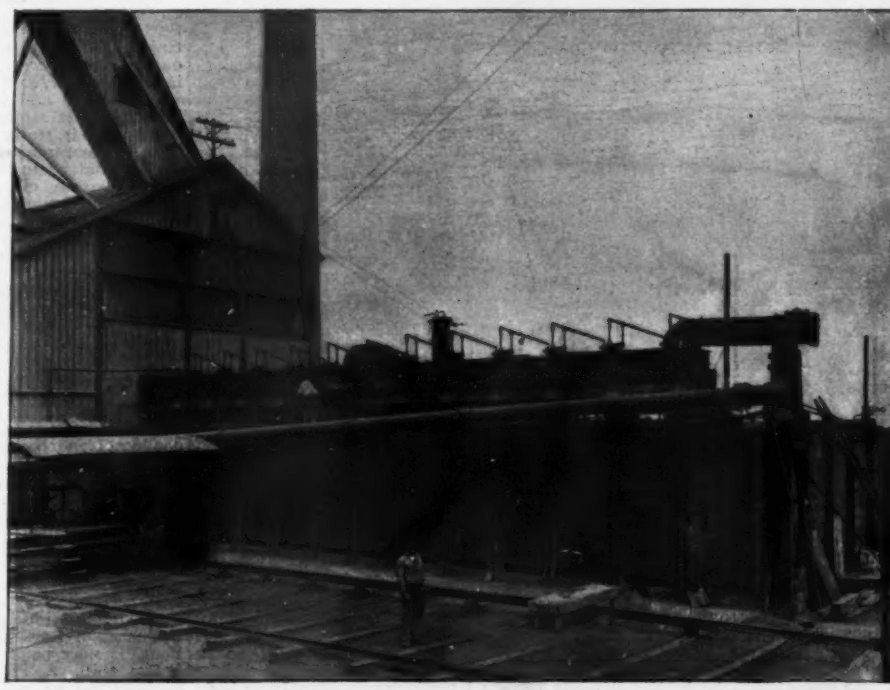
FOREMOST among the great industries of our country now undergoing radical changes is the coking industry. Already the old beehive oven has been eliminated from the coke fields of England, France, Germany and Belgium, and, although at first, seemingly, reluctant to follow in the wake of foreign coke makers, those of our own country have come to realize the inestimable value of the by-product oven systems, and are, accordingly, adopting them that they, like their foreign competitors, may reap millions by saving and utilizing those valuable products of which no consideration whatever is taken by the old coking systems.

The little history we have of the idea of utilizing the valuable chemical constituents given off by coal in the ordinary processes of coking teems with interest. As far back as 1768 tar was produced in a by-product oven, by a chemical process, at Fishback, in the coal fields of Saarbrücken, in the Rhineland province. As early as 1850 the coke makers of England, France, Germany and Belgium had begun systematic experiments on the new processes, and by 1862 a very efficient by-product oven plant was in operation at St. Etienne, in France.

England was not so ready as was Continental Europe to adopt the by-product systems, and the coke makers of that country have not entirely abandoned the old beehive oven. In 1882 Sir Lowthian Bell made experiments, and claimed that coke produced by the by-product method was of inferior quality to the ordinary beehive oven coke, and this adverse report somewhat retarded the introduction of the new process into England; but soon Sir Burnett Samuelson disproved Sir Lowthian's conclusions, and then that experimenter acknowledged his error, and the speedy introduction of the by-product systems followed.

Having thus conquered the old world, these revolutionary coking ideas turned to progressive America to seek entree into her prolific field. While it is a well known fact that in mechanical genius our country leads the world, the coke industry is one of the few exceptions. The right of Europe to pre-eminence in the field of chemistry has not, until recently, been disputed by America, and as the by-product question can readily be resolved into a chemical one, it lay more directly in the field of the careful and learned men of Europe than within the field of the busy American.

The old beehive oven takes its name from its shape. It is usually 10 or 12 ft. in diameter and from 6 to 8 ft. high. It has two openings, one in the top, through which the oven is charged and through which the gases escape, and a door in front through which the air is admitted and the coke drawn. In these ovens it requires forty-eight hours to coke a charge of coal of from 5 to 6 tons. The by-product oven is a closed one, no air being admitted while the coal is being coked. The exclusion of air from the retort oven does away with combustion in the coking chambers of the oven, and the heat necessary for coking comes from combustion of the air and gas in the flues and in the sides and bottom of the oven. In the various systems of the by-product oven its width varies from 18 to 20 in., its height is 7 to 8 ft. and length 25 to 30 ft. It is charged through a number of openings in the top, and the charge runs from 5 to 8 tons. In the by-product systems the coking process is completed in 18 to 20 hours.



THE SEMET-SOLVAY RETORT COKE OVEN, SHOWING PUSHER FOR FORCING COKE OUT OF THE OVEN.

In the beehive oven the mass, as it fuses into coke, swells and rises. If, on quenching, it falls back to its original bulk, it makes a hard coke; if not, a soft coke is the result. The beehive oven makes no provision for the physical improvement of the coke, and, so far as the quality of the product depends upon the oven, it is as primitive and unimproved a construction as when first devised. But, notwithstanding all these disparaging facts, this primitive oven still predominates in the Connellsville region and in other coke fields in this country.

So long as a coal well adapted to coking is coked in these ovens, the results are very good; but, wherever attempts have been made to coke a coal not just adapted to coking, the beehive oven has been a failure.

For the retort oven systems it is claimed that they will readily adapt themselves to the different coals, and must soon come into general use. In the retort oven there is, too, some system about the coking processes, and a uniform coke is produced. When the coal swells, it cannot expand in the narrow chamber. It is compressed both vertically and laterally, and a hard coke is the result. Just as common coke is superior to anthracite for furnace purposes, so is retort oven coke superior to ordinary oven coke. Anthracite coal, at one time a bituminous coal, is really a coke produced by nature. The volatile matter contained in it was driven out by the mighty forces of nature during the earth's chaotic period. It is much freer from volatile matter than is ordinary coke, and contains more carbon, both of which facts tend to enhance its fuel value; but overbalancing these is its density, caused by the immense pressure under which it was produced. In the ordinary oven coke the porosity of the product is great; but toughness and hardness, which are essential qualities of a perfect furnace fuel, are lacking.

THE SEMET-SOLVAY OVEN, SHOWING COKE BEING DISCHARGED.

The porosity of the coke is too great to combine these other essentials. On the other hand, the cell space of the by-product oven coke, while equally as great as that of the beehive product, is more proportionally distributed, and thus combines with this these essentials.

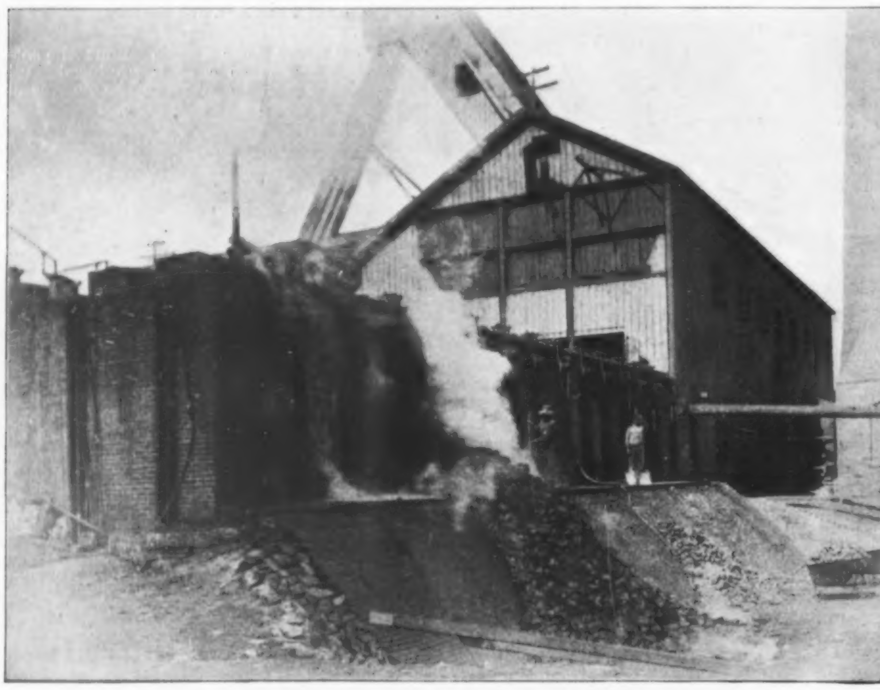
While the by-product oven suffers none in comparison with the beehive oven, we have yet to consider the valuable chemical constituents utilized, all of which are clear gain. Analysis shows that the primary products of bituminous coal are coke, fuel gas, ammonia and tar; and the secondary products are illuminating gas, benzol, pitch, xylol, toluol, phenol, naphthalene, anthracine, creosote, and parydine. By the beehive oven system these valuable chemical constituents are all sacrificed for coke alone. Millions of dollars' worth of these chemicals are going up in smoke from the coke fields of our country every year. If we but thus consider the value of the constituents which make up the seemingly worthless smoke, the matter of utilizing these by-products readily resolves itself into one of the greatest importance.

The government experts on coke and coal have estimated that the entire value of the by-products which the new coking systems propose to utilize cannot be less than 66⅔ cents for every ton of coal coked. In our country there are mined every year nearly 20,000,000 tons of coking coal. These figures make evident the value of these new methods to coke makers of our country. The by-products which will be utilized by the ovens now being introduced are ammonia, fuel gas, illuminating gas and tar. From these by the complexed processes of chemistry are produced aniline dyes, benzol, saccharin and other products. But, great as will be the benefits of the general introduction of these new systems into our coke fields, they cannot be confined to any coke or coal field. As improvement in iron making processes made it possible for iron works to be operated at points remote from the ore pits, so will these new coking systems make it possible to operate coke plants remote from the coke regions. Wherever manufacturing is carried on, wherever fuel is in demand, there is found an open field for these new coking ideas.

Rich as are our industrial resources, we cannot afford to waste the valuable products now going up in smoke from our coke regions, and our coke makers have now come to realize this fact.

Of the retort oven systems with recovery of by-products, which are now being introduced into this country, there are two leading types. The

one, chiefly represented by the Otto-Hoffman form, with vertical flues and regenerative firing; and the other, represented by the Semet-Solvay system, with horizontal flues and continuous recuperation of heat. The former has, for about fifteen years, been in use in Germany, and, under the exploitation of one of the leading fire brick manufacturers of that country, has attained a wide development. There is, however, some question as to the principle of applying the expensive system of the Siemens regenerator to a fuel operation requiring only the moderate heat of the coke oven, and it is manifest that the simpler method of continuous recuperation of the Semet-Solvay system is the more practical.



QUENCHING THE COKE.

The retort ovens are, at the greatest, not more than 8 ft. high, and in the vertical flue system the heat of distillation must do its work in that short space and in a direction where the natural flow of the gas is most rapid. In this method the highest heat is at the top of the vertical flue, while it should be at the bottom, in order to insure perfect distillation. With the horizontal flue making three turns along the side of the oven and one underneath its sole, the gases pass through a circuit of 120 ft., and the opportunity for imparting heat to the interior of the oven is simplified and rendered more efficient as well as more economical. In this system the greatest heat is easily regulated at the lower part of the oven, and the available heat of the fuel is more thoroughly exhausted. This also explains the superiority of the recuperative process over the regenerative.

The grafting of the retort oven system upon the American coke industry has had many infantile vicissitudes. The first permanent by-product plant was not erected until 1891. This was a plant of 12 ovens, erected by the Solvay Process Company, at Syracuse, N. Y. It was put in operation in January, 1892, and since that time has been in continuous operation. At present the plant consists of 30 ovens. In these ovens all kinds of coal has been coked, and the yield has been from 15 to 40 per cent. greater than given by the beehive oven. In numerous tests of the coke produced by this process it has been proved to be superior to the best beehive oven coke. Among the experts who have been conducting tests of the coke produced by the Semet-Solvay by-product oven system are Joseph D. Weeks, government expert on coke and coal; J. J. Dalby, of the Brynbo Steel Works, England; Charles M. Foote, of the Illinois Steel Company; John M. Fulton, of the Johnston Iron Company, and R. M. Atwater.

The successful furnace tests of the coke produced by the Semet-Solvay Company, at the Syracuse plant, have given an impetus to the introduction of the retort oven systems, especially those of the Solvay type. The Dunbar Furnace Company, at Dunbar, Pa., has adopted that system, and at their plant there have now in operation 50 ovens. At Sharon, Pa., a plant of 30 of the Solvay ovens has just been put in operation. At other points the near future will see the erection of ovens of the same pattern.

The by-products utilized by the Solvay by-product ovens are ammonia, tar and gas. Among the advantages claimed for the system are: Simplicity and low cost of construction, rapid gasification, recuperation of waste heat and facilities for repairs. The cost of the ovens will, of course, vary somewhat with the neighborhood in which they are erected. Dr. Spannagel, director of the Phoenix Works, at Ruhrort, Germany, estimates the cost of a complete oven of the Solvay type, with by-product recovery apparatus, at $1,624. The estimated cost of an oven of this type in our country is about $1,400.

The system produces four times as much coke per oven annually as do the beehive ovens, and the value of the by-product utilized is six times as great as is the value of the coke produced by a beehive oven.

At Johnstown, Pa., the Cambria Iron Company have put in operation a plant of 50 ovens of the Otto-Hoffman system, and the United Gas and Coke Company, who are the American agents for this system, are arranging to erect plants at other points. It is now assured that the retort oven system, as represented by these two leading types, will, in the near future, rise and triumph over the old coking ideas as represented by the wasteful beehive oven.

Another by-product system is the English beehive by-product system, which is represented in our country by a single plant of 30 ovens. These have just been put in operation at Latrobe, Pa., by the Latrobe Coke and Coal Company. The operation of these ovens is somewhat different from the systems already described. The ovens are somewhat larger than the regular beehive ovens, but are charged with the same amount of coal. For twenty-four hours the ovens are kept closed, and during this time the by-products, ammonia, tar and gas, are extracted. The gases are first carried from the oven into a condenser, and from there through vertical ventilating flues, and thence to the ammoniacal tanks, and then to the furnaces where the surplus gas is consumed to supply heat for the boilers. When the by-products have been taken off, the ovens are opened and the air is admitted during the remaining twelve hours of the coking process. From the Solvay and the Otto-Hoffman ovens the coke is taken out by pusher, but from the beehive by-product ovens, a coke-drawing machine is used.

While these foreign by-product systems have been striving to obtain favor with American coke makers, American genius has not been entirely dormant. The early introduction of these systems set the minds of our coke makers to work, just as their introduction into England had aroused the coke makers of that country, and here, as there, a new system has been evolved.

The new American retort oven system was designed by Mr. Laughlin, manager of the Laughlin Furnace Company, of Pittsburg, Pa., after an examination of the retort oven systems of Belgium, Germany and England. As yet, Mr. Laughlin has not perfected the apparatus for the recovery of the by-products. An experimental plant of 20 ovens has been erected, and within the next few weeks a test will be made. The ovens of the plant are 18 in. wide, 12 ft. deep and 15 ft. vertically. The coking chambers are perfectly airtight, and in them will be made a 24 hour coke, and by the system of checkers, it is hoped that a coke will be obtained from which all chemicals which act deleteriously will have been eliminated.

The last few months have been momentous ones for the by-product oven ideas. Early last summer New York, Philadelphia and Pittsburg capitalists closed a deal for 15,000 acres of rich coal lands in Western Pennsylvania, and by next summer will have in operation six batteries of 360 retort ovens, which will be erected at a cost of $2,500,000.

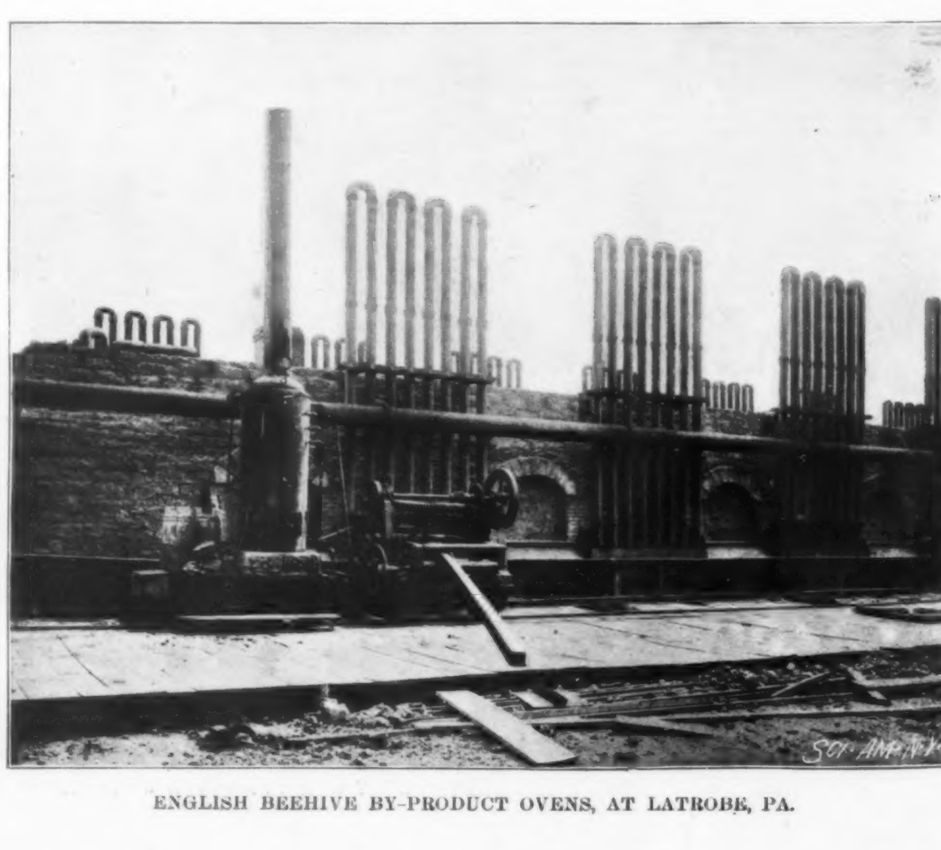
The Bessemer Coke Company are erecting a plant in the Connellsville region which will cost $1,000,000. In the West Virginia, in the Ohio, in the Indiana, and in the Illinois coal fields, these new ideas will be speedily introduced. Iron and steel manufacturers, gas companies, railroad magnates and other capitalists are interested in these new coking processes, and it is certain that they will early triumph over the old beehive oven system.

BOILER SCALE AND ITS CURE.

HEREWITH is presented a summary of a recent report on boiler incrustation and its removal by the Bavarian Society for Boiler Inspection, says the Iron Industry Gazette. Feed water for boilers may contain as injurious components: Incrustants, fatty and corrosive ingredients, air, and other gases.

Incrustants and their Nature.—1. Water, free from incrustants, is seldom found in nature, but condensed water, that is, water produced from steam by cooling, does not contain any incrustants. 2. Incrustants are partly admixed mechanically to the feed water (sand, finely separated clay, in muddy water), partly dissolved (clear water from wells). 3. The principal incrustants are: Lime, gypsum and magnesia, which occur concurrently in almost every feed water in larger or smaller quantities. 4. The quantity of incrustants contained in a certain feed water does not always remain the same, but changes, as a rule, with the weather. 5. The incrustants, dissolved in water, are separated by the heating and evaporating of the water, either in the form of powder or precipitated as slime, or they adhere to the hot boiler walls as a solid crust, the formation of which is promoted by the gypsum contents of the water. 6. A peculiar form of incrustation are the "crust cakes," which will form in some boilers, when the solid crust is caused to crack off by the partial cooling of the boiler during stoppages. The pieces collect usually on the firebox sides in lumps that are highly injurious to the proper working of the boiler, and even dangerous.

Injurious Effects of Incrustation.—1. Incrustation causes a number of annoyances and expenses, by necessitating the cleaning of the boiler or the purification of the feed water, repairs, stoppages and by losses of heat or fuel, which originate from stopping, starting and the cooling off of the boilers, necessary for cleaning or making repairs. 2. The most injurious effect of incrustation is, that by obstructing the passage of heat, it may cause a dangerous overheating of the boiler wall. 3. This overheating is caused by solid incrustation as well as by slimy deposits, and results in leaks in the joints, riveting and flues. It is also a prolific cause of cracks around the rivet holes and of tubing. 4. It causes in the neighborhood of the firebox bulgings, either outwardly or inwardly, and an ultimate cracking of the boiler, which frequently results in explosion. 5. Incrustation and slime cause, by overheating, an unequal expansion of the boiler walls and promote thereby, apart from the gradual weakening of the boiler, the sudden formation of cracks, especially of the highly dangerous cracks through the rows of rivet holes—another fruitful source of explosions.



ENGLISH BEEHIVE BY-PRODUCT OVENS, AT LATROBE, PA.

6. Incrustation and slime stop up feed pipes, especially their mouths, water and steam gage tubes, promote the leaking of cocks and valves, and can even be carried by the steam into the engine, where they assist greatly in wearing out slide valves, piston and cylinder.

How to Prevent Incrustation.—Incrustation and its injurious effects are prevented by the proper selection of the feed water and boiler system, by the purifying of feed water, and cleaning of the boiler.

Selection of Feed Water and Boiler.—1. Where different waters (well, hydrant, or running water) are to be chosen from, that water should be selected, by means of chemical analysis, which contains the least incrustants and other injurious components. 2. Where different waters are at disposal, it is sometimes advisable to mix them or to feed them alternately to the boiler. 3. All the condensed water should be collected carefully and utilized for feeding the boiler. 4. If water rich in incrustants has to be used without previous purification, a boiler should be selected the interior of which is easily accessible, so it can be cleaned thoroughly at all places. Boilers with narrow spaces inside, as, for instance, water tube boilers, should be selected only when pure or purified feed water can be had. 5. Whenever the construction of the boiler may permit it, it will be found very useful to provide those places where accumulations of powdery or slime depositions usually collect with slime bags or catchers. In any event, special attention should be paid to the installation and maintenance of the apparatus serving for the removal of the slime. 6. As many waters deposit a considerable proportion of incrustants, when simply heated, it is advisable to provide the boiler battery with a feed water heater, in which the feed water is heated as much as possible by exhaust steam or furnace gases before it enters the boiler.

Purification of Feed Water.—1. The best means to prevent incrustation is the purification of the water, or the removal of the incrustants before the water enters the boiler. 2. A very simple and tried method for purifying water is that by caustic soda or lime. 3. In order to ascertain whether and how a certain feed water can be purified to the best advantage, it is necessary to have a sample of it analyzed. The sample should be put in a clean glass bottle and not be less than one gallon.

The Cleaning of the Boiler.—The cleaning of boilers is accomplished by knocking or scraping off the incrustation or boring it out and by partial or entire removal of the slime by washing and rinsing; indirectly, by additions to the feed water, which keep the incrustants in solution or in the form of slime, or in such a condition as to facilitate its removal by washing.

Scraping and Washing.—1. Solid incrustation is to be removed thoroughly by means of suitable tools. 2. To make the removal of solid incrustation easy, a thin coat of suitable paint may be applied to the inner surface of the boiler walls. 3. As the incrustants are frequently deposited in the form of powder or slime, it is well to remove the slime before it becomes solid by burning. Partial or entire emptying of the boiler answers this purpose; the former could be done once or several times a day at suitable times. 4. A boiler to be emptied should be allowed to cool off fully, together with the masonry, before the water is let out. Hereby the burning of the slime to a solid crust is prevented. 5. In order to quicken the cooling of the boiler without danger to the latter, as much cold water should be fed from above as runs out below, and continue until the boiler has fully cooled off. Additions to the feed water: 6. In order to keep the incrustants in solution or in the form of slime, which is of great importance in the case of boilers with narrow spaces inside, an addition of caustic soda to the feed water can be employed in most cases to the best advantage. 7. As regards the proper quantity of this addition, it is best determined by chemical analysis of the feed water.

When to Clean a Boiler.—1. How often a boiler should be cleaned from incrustation and slime depends partly upon the quality and quantity of the evaporated water, partly upon the construction of the boiler, and is best determined by experience. 2. Thin incrustation, not thicker than an egg shell, near the firing, is not injurious. It is frequently of benefit even, as it protects the boiler wall from the influence of injurious components of the feed water. 3. If the incrustation be thicker than indicated above, it should be removed. In urgent cases it would be sufficient to clean those parts of the boiler that are nearest to the firing. 4. If "crust cakes" and slime piles accumulate as a rule on the boiler wall above the firing, it is necessary to remove them at least every two weeks, otherwise cracks and explosions may be caused. 5. Boilers with narrow spaces inside, for instance, tube boilers and boilers of traction engines, should always be cleaned carefully and in time. 6. If a boiler be put in operation for the first time with feed water the properties of which are not well known, it would be advisable to empty it after two to four weeks, and ascertain how much, in what form, and on what places incrustation and slime have been deposited. The same rule applies to every new boiler, or when the manner of operating a boiler is changed.

Fatty Components.—1. The feed water carries generally fatty parts along, when it has been heated by direct contact with the exhaust steam of an engine, the parts of which are greased with animal or vegetable oils, or when the water from an engine with condensation is used for feeding the boiler. 2. Feed water, made greasy in this manner, should be used with caution, because grease, together with powdered incrustants, consisting of lime or magnesia, forms a soaplike mass which adheres tightly to the plates, and causes easily an overheating of the boiler walls. 3. From oils and greases fatty acids are formed in the boiler, which attack the boiler walls at different places, especially along the water level. 4. These evils are remedied by using good mineral oils for lubricating, or by filtering the water before it enters the boiler. It is true that an addition of soda will counteract the injurious effects of grease, but it may cause the boiler water to foam and to boil over.

Corrosive Components.—1. Many feed waters, especially those coming frem mines, moors and chemical factories, contain free acids, by which the boiler walls are attacked and corroded. 2. The same effects can also be produced by various salts, contained in nearly all feed waters in larger or smaller quantity; for instance, chloride of magnesia. 3. Feed water taken from very deep wells or from wells and reservoirs located in the neighborhood of chemical factories, dung piles and sewers, also contains frequently corrosive components, which act injuriously upon the boiler walls. 4. The best protection against the corrosive components of the feed water is offered by an addition of soda.

Air and Other Gases.—1. Every feed water contains more or less air, which, as soon as the water begins to boil, is expelled and escapes together with the steam out of the boiler. 2. When air thus expelled cannot escape freely, it will form bubbles upon the places of obstruction; for instance, at the top of the lower boiler (heater), which cause the corrosion of the plates at those places. 3. In those parts of the boiler where the water does not reach the boiling stage, but is heated up only, the air contained in the water adheres to the boiler in the form of little bubbles. 4. These bubbles cause the pockmarklike corrosion of the boiler walls, which is strongest when the circulation of the water in the boiler is slow, or the water is fed rather cold. 5. There are other gases, chiefly carbonic acid gas, found in feed water and causing effects similar to air. 6. Preventives against the injurious action of air are: Proper construction and mounting of the boiler, so that the air bubbles can freely escape into the steam chamber, or providing air exhausts; providing for lively circulation in the boiler, by avoiding too wide heaters; removal of the air from the water, before its entering the boiler, by its highest possible heating in open vessels; placing the mouth of the feed pipe in the steam chamber, or near the water level, and avoiding everything that might aid air to enter the water; for instance, regulation of the water stage by means of air cocks.

AERIAL PHOTOGRAPHY BY KITES.

WHEN, in 1888 and 1889, I published in this place the results of my first experiments in aerial photography with kites, and when later, in 1890, I published the details of my process in pamphlet form, I had certain improvements in view, but a considerable length of time and numerous experiments were necessary in order to render them practical. I had to modify my material, and it is of such modification that I wish to speak, in showing the specimens that they have enabled me to obtain.

FIG. 1.—VIEW OF LABRUGUIERE (FRANCE), TAKEN BY KITE PHOTOGRAPHY.

I have constructed my kite in such a way that it may be taken apart, so as to render the carriage of it not only possible but easy. To this effect, the external string of the kite, instead of being fixed to the extremity of the sticks of the frame, simply embraces them through four loops. For paper, which is too easily torn and not sufficiently extensible, I have substituted China silk (ponghee). The two sticks forming the frame are united by a thumb screw. It will be seen from this how easy it is to put the apparatus together and take it apart. The tail, for whose ingenious arrangement I am indebted to Engineer Ferdinand Potter, consists of a narrow strip of fabric frayed on each side, and in the axis of which, for the sake of greater strength, is sewed a light cord. This tail, which takes the wind very well, presents the great advantage of not getting tangled up.

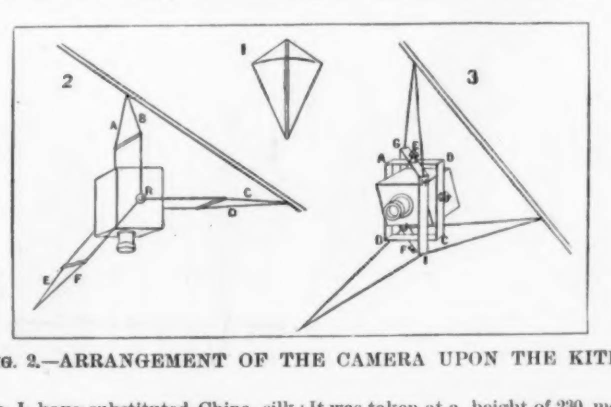


FIG. 2.—ARRANGEMENT OF THE CAMERA UPON THE KITE.

I have had to give up the sliding shutter placed in front of the objective, and substitute for it a rotary one arranged between the lenses and actuated by a strong strip of rubber. Rapidity is here a factor of the highest importance, especially in certain winds subject to frequent changes of direction and intensity due to the reliefs of the ground that they sweep.

Finally, I have ceased fixing my camera to the center stick of the kite—a defective arrangement, in that it increases the latter's weight and thereby likewise increases the pull that it exerts upon the maneuvering string. Mr. Emile Wenz, of Rheims, conceived the idea of suspending the camera in the converging strings of the kite. This happy arrangement, by diminishing the traction of the latter, permits of the use of a weaker and consequently lighter string. I have, therefore, adopted Mr. Wenz's ingenious arrangement, but in modifying it in such a way that either a vertical or a perspective view may be taken in front, behind, to the right or to the left.

My camera is provided with two bolts, one of them placed to the right and the other to the left, about in the center, and permitting it to be revolved thereon around its horizontal axis at right angles with the optical axis (Fig. 2).

If it is a question of a vertical view, I suspend it with the objective turned toward the earth, in an arrangement consisting of two wooden rings, R (No. 2), fixed at the junction points of the two head strings, A B, of the two tail strings, C D, and of the two strings, E F, that connect with the maneuvering string. Light strips of bamboo maintain a sufficient space between these strings to allow the camera, suspended from the rings by its two bolts, to revolve freely. After a vertical position has once been secured, a tightening of the nuts maintains it.

If I wish to take a perspective view at any angle whatever, either in a vertical or a horizontal plane, I suspend the camera by its two bolts in a light frame, A B C D (No. 3), which is itself fixed by two other bolts, one at the top and the other at the bottom, in a second frame, G H I J, at which end the converging strings. I can then turn the optical axis of the apparatus to the right or left of the line of the wind, toward the front or back of the kite, incline the axis toward the earth at any angle that seems proper, or direct it upon the horizon.

In order to facilitate these different maneuvers, I arrange the strings of the kite in such a way that when the latter is in its position of equilibrium (about 35° upon the horizontal), the frame, G H I J, shall occupy an almost vertical position.

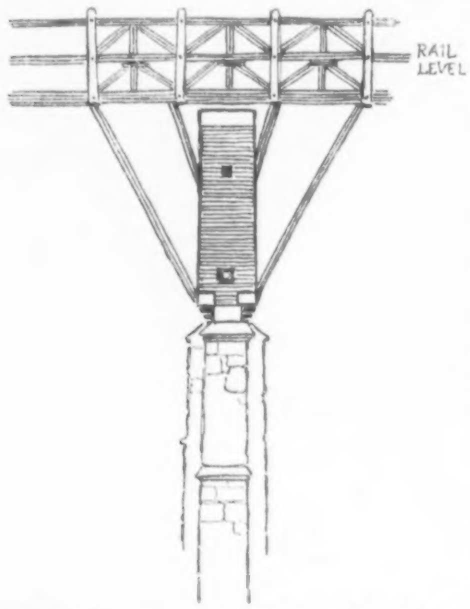
The photograph (Fig. 1) that accompanies this article gives a general view of the small town of Labruguiere. It was taken at a height of 230 meters above the earth in a S. S. E. wind, the objective being directed to the N. E. and inclined toward the earth at an angle of 45°. Another photograph was taken in the same wind, at the same vertical angle and at the same height, but the objective was directed toward the north. It reproduced the west faubourg, limited to the left by the railway from Castres to Mazamet.

An interesting peculiarity of these two negatives was that they reproduced one portion in common. The

factory and park seen at the base of the first were found again in the center of the second. It would therefore be possible, thanks to Col. Laussedat's topographical method, to draw a plan of this part of Labruguiere. —Arthur Batut, in La Nature.

THE COLDRENICK VIADUCT DISASTER.

The dreadful accident on the Coldrenick Viaduct of the Great Western Railway on Tuesday, February 9, by which twelve men lost their lives, was probably



METHOD OF CARRYING UP THE PIERS.

TREVEDO VIADUCT.

caused by the recklessness which men long employed in situations the most hazardous nearly always develop. Works are in progress on this, one of the younger Brunel's timber and granite viaducts, by which the Cornwall Railway was carried over the deep Cornish coombes; works which have for their object the widening of the line from a single line railway to one up and one down set of rails, and these involve the removal of the timbering which, during the last thirty years, has safely carried the permanent way.

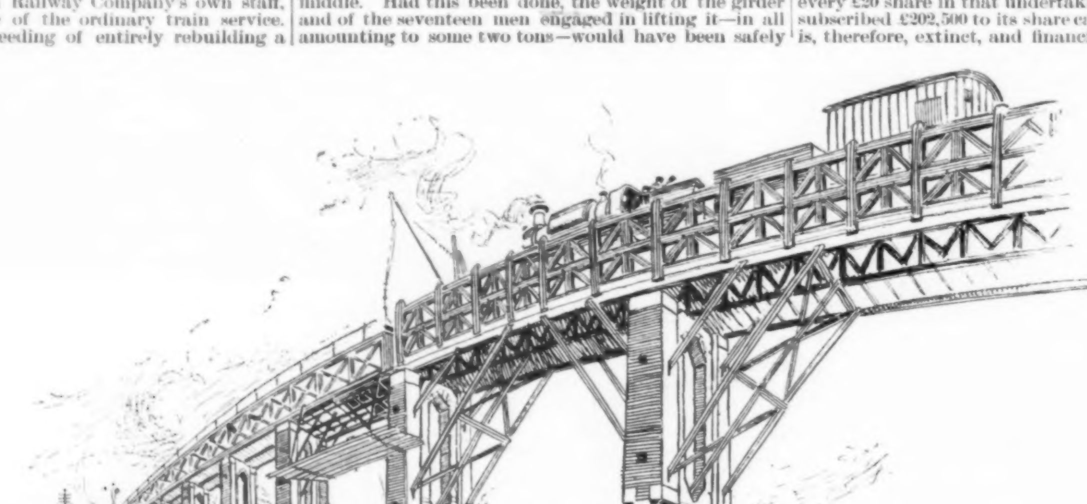
The work on the Coldrenick Viaduct has been in hand for about twelve months, and is being carried on by the Great Western Railway Company's own staff, without any stoppage of the ordinary train service. Unlike its usual proceeding of entirely rebuilding a viaduct from its foundations, the company adopted a plan by which the upper part of each one of the thirteen piers of the structure that carries the line over the Coldrenick Woods was first rebuilt in blue brick with granite quoins, and then the oak timbering is replaced by lattice girders. These rebuilt upper stages have the most singular appearance, and one that looks not a little dangerous where the new brickwork narrows down to meet the granite placed in position over thirty-five years ago. This, together with the lateral warping of the timber trusses, as seen from under the spans, is calculated to impress the beholder very fully with the daring nature of Brunel's works.

The operations were begun from the western end of the viaduct, at which stands the wayside station of Menheniot, and had been safely carried on through the summer and autumn of last year until now, when the reconstruction had gone just half way. It was here, where the seventh span carries the line over the deepest part of the valley, 150 ft. above the little brook that murmurs among the stones at the bottom, that the unfortunate men who were killed were working on a staging suspended under the line. Their method was to fix two ballast rails across the span, as a foundation, and to place a flooring of planks across these. The longitudinal timbers strutting out from the piers were counted upon to sustain the weight of the 7 cwt. girders dragged across the opening. These timbers are 8 in. by 6 in.; and the company's engineer stated, subsequently to the accident, that instructions had been issued for a chain to be passed round the main timbers of the viaduct, to support this platform in the middle. Had this been done, the weight of the girder and of the seventeen men engaged in lifting it—in all amounting to some two tons—would have been safely supported. As it was, the staging could only have borne 15 cwt., and a balk consequently collapsed, with the consequences already alluded to.

Although the whole of the picturesque half timber viaducts on the Great Western Railway, numbering originally between forty and fifty, are to be replaced with solid granite structures, it must not be supposed that they have generally been condemned as dangerous.

The growth of the traffic to and from the west, necessitating a double line instead of the single one between Plymouth and Penzance, has, together with the introduction of heavier locomotives, rendered these changes imperative on this 76 miles stretch of railway. Brunel did not foresee the increase; or, more likely, the directors of the Cornwall and West Cornwall Railways had not the capital necessary for a double line, and so the railway has remained all these years a single line, worked on the staff system.

It was not until comparatively recent years that the whole of the line to Penzance became the property of the Great Western Railway Company. Many who have not reached middle age can recollect seeing on the rolling stock below Exeter the initials of the South Devon Railway, which began where that other line, the long absorbed Bristol and Exeter Railway, ended. The South Devon was bought up, and the Great Western Railway leased and worked the Cornwall and West Cornwall Railways, which extended respectively from Saltash to Truro, and from Truro to Penzance. The Cornwall Railway was purchased November 16, 1888, the Great Western Railway Company giving £8 for every £20 share in that undertaking, having previously subscribed £202,500 to its share capital. That company is, therefore, extinct, and financially, as well as physically, the road forms a part of the Great Western main line. The Great Western Railway encounters through the greater part of its long span a remarkable series of engineering difficulties. The great stone and timber viaducts commenced in Devon with the Blackford Viaduct, across the valley of the Erme, outside Ivybridge station. This has been rebuilt of late years in granite,

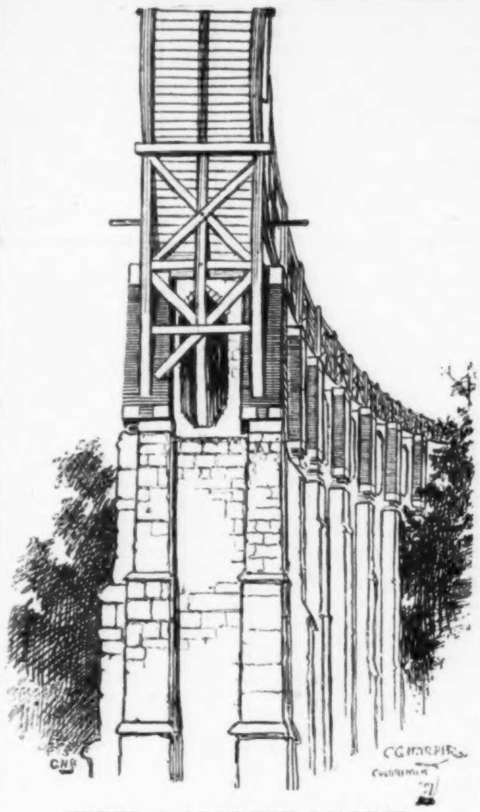


COLDRENICK VIADUCT ON THE GREAT WESTERN RAILWAY.

having been strengthened twenty years previously by the introduction of iron girders. The contractors were Messrs. Pearson & Son. Its height is 100 ft., and in its rebuilt condition it consists of eleven spans of 63 ft. each. The Cornwood Viaduct has also been rebuilt, together with three smaller buildings. A number of smaller wooden structures remain on the main line in the neighborhood of Plymouth; the Pennycomequick Viaduct and two others—those of Westonmill and Keyham—bridging the shallow, muddy creeks of the Hamoaze between Saltash and Plymouth. But it is after the Royal Albert Bridge at Saltash is passed that one comes into the land of viaducts. Scarce a mile, and often not a quarter of a mile, separates these lofty and graceful flights across the ever recurring deep Cornish coombes and picturesque gullies. The first is a little beyond Saltash Station, and spans Trematon Creek. It was rebuilt in 1894; five old viaducts remain between this and St. Germain's Station. The greatest activity in rebuilding is to be observed between St. Germain's and Menheniot, on which section is situated the Coldrenick Viaduct, which has given rise to these remarks. Here also the Trevalga and Tresulgan viaducts are being rebuilt. On the down side of Menheniot Station, half a mile distant, the Treveddo Viaduct is being entirely reconstructed. The old building, which goes on a curve over the Treveddo Woods, is of eight spans. In common with Coldrenick, it is remarkable for the singular absence of anything like uniform pattern in the buttressed granite piers that come tapering up from the valley. From their summits a very forest of timbers springs out, fan shape, and supports the road. Elaborately shoed and "pickled," bolted through and stayed by a maze of iron ties, the timber work of Treveddo is among the most extraordinary of the series. Messrs. T. Relf and Sons have the contract in hand, and several arches of the new viaduct are already turned. The road hereabouts is being graded down some 6 ft. The next is Liskeard Viaduct, on the up side of the station, widened and reopened Christmas, 1895; while the greatest piece of rebuilding on the line occurs on the down side, at Moorswater. The Moorswater Viaduct is 800 ft. long and 150 ft. high, and was reopened February 26, 1881. It was three years in building, and cost £30,000; an immense sum for one of a large series of works to be undertaken by an independent company, as the Cornwall Railway then was, although backed by the Great Western. From here to Doublebois the railway goes halfway up the hillside, through miles of woods; but between Doublebois and Bodmin road there are ten viaducts, all rebuilt.

The branch from Bodmin road to Bodmin, opened about ten years ago, was a supremely difficult and expensive line, the greater part of its 3½ miles being viaducts.

Then past Lostwithiel and Par, and so on to St. Austell, there is only one viaduct all the way, and that not a large one. Between St. Austell and Burngullow, however, there are two in course of rebuilding—the Trenance Viaduct, immediately past St. Austell Station, and that of Gover, a quarter of a mile further—both in urgent need of being replaced. Between Burngullow and Grampound road there are two, rebuilt; and thence onward to Truro Station are three old ones—those of Carkennick, Carvedras, and Truro—shortly to be taken in hand. Below Truro, the Falmouth branch, 11⅓ miles long, goes off at Penwithers Junction, where a long curved old timber and granite viaduct crosses the valley. This also is a branch remarkable for the number of these interesting structures, including such long and lofty examples as those of Ponsanooth, Trelievet, and Collegewood.



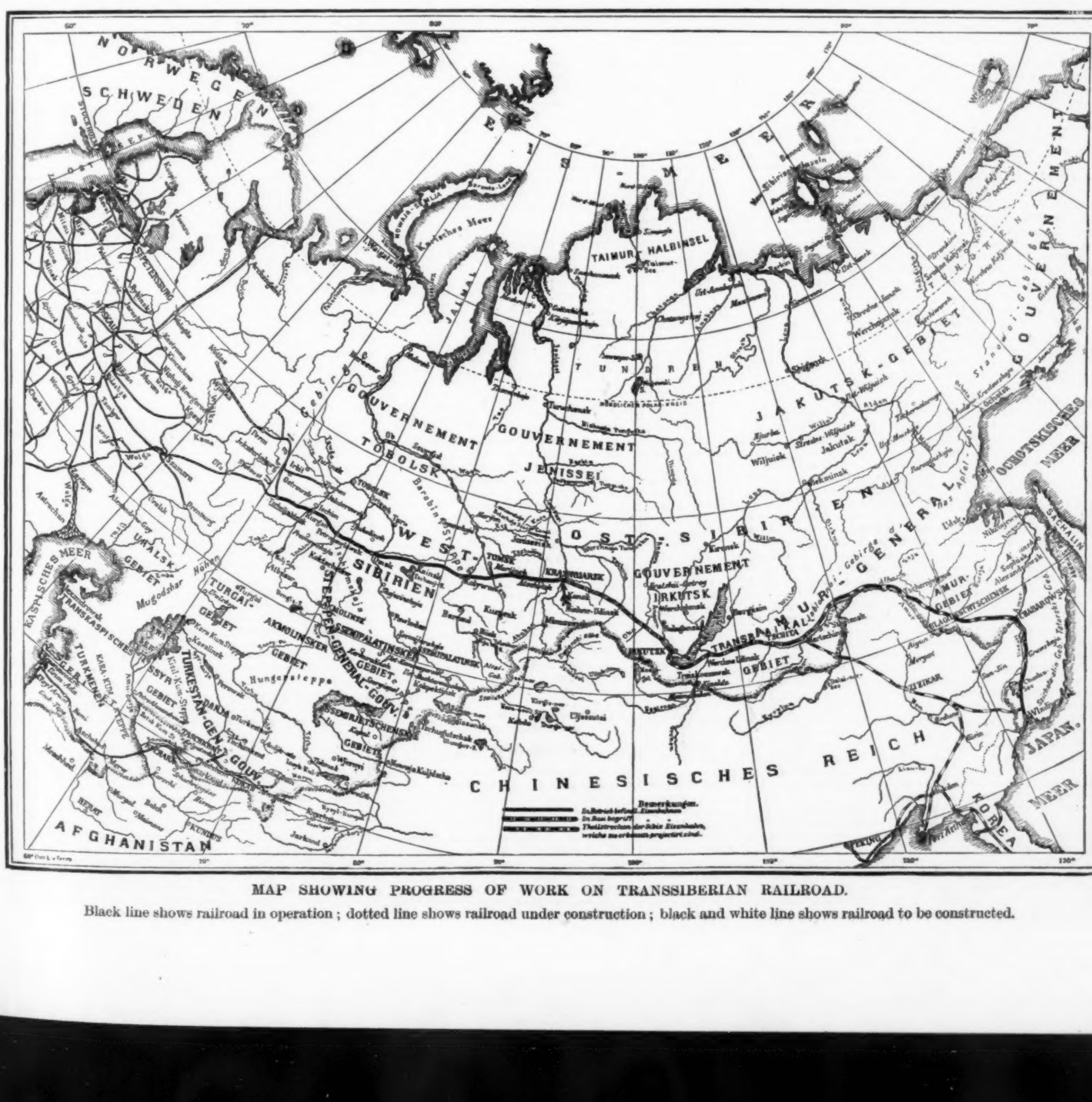
UNDER COLDRENICK VIADUCT.

Below Truro, on the main line to Penzance, formerly that of the West Cornwall Railway, there are two lengthy rebuilt viaducts before Chacewater Station is reached and one other just below Redruth Station. The long Stray Park Bridge between Carn Brea and Camborne has recently been finished in granite. One other half timber viaduct remains on the line westward; that of Penpons, between Camborne and Gwinear road, and this is being discarded in favor of an embankment. Finally, there are two new viaducts between Gwinear road and Hayle; the railway onward, through St. Erth and Marazion to Penzance, going through easier country until it runs into the Penzance terminus along two miles of flat marshes and the sandy shores of Mount's Bay.—Engineer.

THE TRANSSIBERIAN RAILWAY.

WHILE it is well known that the Russian government has been displaying extraordinary activity in pushing the work on the great Transsiberian Railway, the magnitude of what has been accomplished and of what remains to be done is not fully realized by most people. It will, therefore, be of general interest to state the present condition of the undertaking and the progress to be expected in the near future.

The Transsiberian Railway has its western terminus at Tschelyabinsk, where it connects with the railways of European Russia. It then proceeds in a mainly eastern direction to Krasnoyarsk, on the Yenisei River, at 2,654 kilometers (1,648 miles) from Tschelyabinsk and 4,919 kilometers (3,057 miles) from St. Petersburg. Krasnoyarsk is at present the eastern terminus of the completed section of the railway. By looking at the map, it will be seen that Krasnoyarsk is located in the very center of Siberia; in fact, the Yenisei forms the dividing line between Eastern and Western Siberia. As nearly all rivers in Siberia have a northerly course, the railway crosses most of them, necessitating the construction of a large number of bridges. Particular difficulties will be encountered on the section east of Irkutsk. According to the plan shown on the map, it was contemplated to have the railway follow the southern bank of Lake Baikal, but as this region is very mountainous, unexpected delays and expenses were liable to arise. It has now been decided to ferry the trains across the lake, a distance of not quite 20 miles, whereas similar ferries are successfully operated in this country for distances over 60 miles. Of the



MAP SHOWING PROGRESS OF WORK ON TRANSSIBERIAN RAILROAD.

Black line shows railroad in operation; dotted line shows railroad under construction; black and white line shows railroad to be constructed.

eastern section of the railway, the portion from Wladiwostok on the Pacific to Grawskaya has been open to traffic for some time, and the northerly continuation to Charabowsk on the Amur will be completed very soon, if it is not completed already. From Lake Baikal to the Amur, the line, instead of following the originally planned northern course indicated on the map, will take the more direct southern route through Manchuria, the Russian government having secured the consent of China to this alteration. This will shorten the line by 1,069 kilometers (664 miles) and will open to traffic a region densely inhabited and rich in natural products, but poor in industries. This transbaikal section will probably be completed last. Connections will be made as shown on the map, to Mukden, Port Arthur, Pekin and Corea, thus linking China and Corea to the civilized world.

Work is being pushed very rapidly on the section from Krasnoyarsk to Irkutsk, no less than 70,000 hands being employed on the line and in the workshops. It is expected that next summer the railway will be completed as far as Irkutsk, the largest city of Siberia (about 50,000 inhabitants). The Russian budgets for 1896 and 1897 clearly show the importance of the work. Thus for 1896 82,248,170 rubels (about $45,000,000) were provided for the construction of the Transsiberian Railway, while there was an additional item of 2,485,410 rubels (about $1,350,000) for the construction of branch lines connecting with the Transsiberian Railway, and 20,000,000 rubels (about $11,000,000) for rolling stock, the greater part of which certainly was intended for the Transsiberian Railway. The budget for 1897 calls for 61,124,110 rubels (about $33,500,000) to be expended on the Transsiberian Railway proper and 3,280,652 rubels (about $1,800,000) for branch lines connected therewith. The total cost of the work has been estimated at 350,000,000 rubels (about $190,000,000), and of the whole length of 7,317 kilometers (4,448 miles), 2,654 kilometers (1,648 miles) have been completed. The length of the Canadian Pacific Railway is only 4,915 kilometers (3,055 miles), so that the Transsiberian Railway will exceed it by 1,393 miles. The completion of the Transsiberian Railway may be expected before the end of the nineteenth century.

Political considerations principally have induced Russia to undertake this great work, but the industrial and commercial development to which the construction of the railway will undoubtedly lead has likewise been of considerable weight in deciding the government to start and actively push the enterprise. It is evident that Russia and Siberia will profit largely by being able to exchange their products in much shorter time than hitherto. The completion of the railway, however, will also affect the trade of the extreme East, as many goods which are now shipped to China and Japan through the Suez Canal will then be forwarded via Siberia.

China, Japan and Corea have an aggregate population of about 460,000,000, but their trade with Europe and with the rest of the world is as yet entirely out of proportion with the extent of their territories and with the size of their population. When China will have opened all its seaports and inland ports to foreign trade, the densely inhabited inland provinces, which are now practically closed to foreigners, will be made accessible to international commerce. The Transsiberian Railway will pass through Manchuria, as above mentioned, and branch lines will probably run to other Chinese provinces; the line to Port Arthur will probably be among the first to be constructed. China's main export articles are tea and silk, while the largest importations are in cotton and wool (yarns and textile fabrics). Great Britain handles most of the Chinese exports in tea. At the same time, Great Britain competes successfully with China in the growing of tea, the plantations in India and Ceylon supplying most of the tea consumed in Great Britain, and also exporting large quantities to other civilized countries. In this competition India is considerably better off than China by having railways leading to the seaports, while Ceylon has at least the advantage of a shorter journey by sea than that from China.

Owing to these conditions, the exports of Chinese tea have decreased, causing a considerable loss to the Chinese people as well as to the government, in view of the fact that there is a heavy export duty on tea in China. The continued decrease in the exportation of tea has become a serious question for China. After the completion of the Transsiberian Railway, China will be able to send her tea to Europe overland much quicker than by sea. It is, moreover, well known that tea sent overland is superior to that shipped by sea. Silk goods also will reach Europe via Russia. The gain of the latter country will be as great as China's, and it will be obvious that the interests of both countries meet in this respect. Russia also is a large consumer of tea, and will probably do a lively trade in this commodity with China. Cotton, woolen and metal goods, which are now imported into China chiefly from England and Germany, will be sent on the new railway, and the industrial works of the Ural Mountains and of Siberia will be enabled to dispose of their goods with greater facilities than their western competitors. Siberia itself will probably have an era of surprising prosperity. The country is rich in mineral and agricultural resources, and as the railway will cross most of the rivers at points where they are navigable, the distribution of goods over the whole country will be made remarkably easy.

After its completion, the Transsiberian Railway will form the shortest connection between Europe and eastern Asia. Prior to January 1, 1897, the trains on the western section of the railway ran at an average speed of 28 kilometers (about 17·4 miles) per hour. Since that time express (?) trains of an average speed of 33 kilometers (20½ miles) an hour have been added. Omsk can now be reached from Moscow without change of cars in less than four days. Moscow can be reached from Berlin in forty-two hours, and from St. Petersburg in fourteen hours. The journey from Berlin to Irkutsk will take from eight and a half to nine days, and that from Berlin to Wladiwostok, on the Japanese Sea (Pacific Ocean), about fourteen days, and might easily be made in twelve or thirteen days.

The strategic importance of the railway will be obvious in view of possible complications in the extreme East. It will be seen that Russia could easily transport troops from Moscow to Wladiwostok, near the Corean boundary, in about sixteen or seventeen days. It has been stated by the English press that troops from England or Scotland, embarking at Liverpool, would land in Canada about ten days later and would be ready for again embarking at Vancouver within a week after their arrival in America, reaching the Yalu River at about the same time as Russian troops dispatched from Moscow. There has been just a slight error in the calculations of the English press, for it will appear from the figures quoted above that the Russians would probably arrive at the Yalu before the Highlanders or other British troops would even have left the American continent.

A comparison of the several routes by which Yokohama in Japan will be accessible after the completion of the Transsiberian Railway clearly shows the advantage of the latter route. The journey from London to Hong-Kong via Brindisi and Suez, employing the steamers of the Peninsular and Oriental Steamship Company, is made in thirty-four to thirty-seven days; one day or two is allowed at Hong-Kong, and six to eight days for the passage from Hong-Kong to Yokohama, making forty-one to forty-seven days in all. From Berlin, Yokohama may be reached in forty-two days via Naples, taking there the steamers of the North German Lloyd. The journey from London to Yokohama via Canada will not take more than twenty-nine or thirty days at present. But a further saving of ten or eleven days will be effected when the Transsiberian Railway will be completed, as the time from Berlin to Yokohama will then be reduced to eighteen or twenty days. A line of fast ocean steamers will connect Wladiwostok and Japan. It is also probable a new transpacific line of steamers will run from San Francisco, and it is stated that American and Russian capitalists have already taken steps toward founding a company for that purpose.

It, therefore, will be evident that the Transsiberian Railway will be a work of international importance. It will be a new and important export route for valuable Chinese and Japanese goods; it will be an import route for manufactured articles, especially from Russia, to the northern Chinese provinces of Mongolia and Manchuria; and lastly, it will be of immense value for passenger traffic from Europe to China and Japan, besides giving Russia a decided political and strategic preponderance in the far East.

For the map reproduced herewith and for part of the information contained in this article we are indebted to Illustrirte Zeitung, while other data have been taken from Uhland's Wochenschrift and from the report of the Russian minister of communications, as published in Glaser's Annalen.

A CONVENIENT METRIC CONVERSION TABLE.

THE following metric conversion table has been compiled by Mr. C. W. Hunt, M. Am. Soc. M.E., president of the C. W. Hunt Company, of New York City, and is most convenient in dealing with metric weights and measures:

Millimeters × .03937 = inches.
Millimeters ÷ 25.4 = inches.
Centimeters × .3937 = inches.
Centimeters ÷ 2.54 = inches.
Meters × 39.37 = inches. (Act of Congress.)
Meters × 3.281 = feet.
Meters × 1.094 = yards.
Kilometers × .621 = miles.
Kilometers ÷ 1.6093 = miles.
Kilometers × 3280.7 = feet.
Square millimeters × .0155 = square inches.
Square millimeters ÷ 645.1 = square inches.
Square centimeters × .155 = square inches.
Square centimeters ÷ 6.451 = square inches.
Square meters × 10.764 = square feet.
Square kilometers × 247.1 = acres.
Hectares × 2.471 = acres.
Cubic centimeters ÷ 16.383 = cubic inches.
Cubic centimeters ÷ 3.69 = fluid drachms. (U. S. P.)
Cubic centimeters ÷ 29.57 = fluid ounce. (U. S. P.)
Cubic meters × 35.315 = cubic feet.
Cubic meters × 1.308 = cubic yards.
Cubic meters × 264.2 = gallons (231. cu. in.).
Liters × 61.022 = cubic inches. (Act Congress.)
Liters × 33.84 = fluid ounces. (U. S. Phar.)
Liters × .2642 = gallons (231 cubic inches).
Liters ÷ 3.78 = gallons (231 cubic inches).
Liters ÷ 28.316 = cubic feet.
Hectoliters × 3.531 = cubic feet.
Hectoliters × 2.84 = bushels (2150.42 cubic inches).
Hectoliters × .131 = cubic yards.
Hectoliters ÷ 26.42 = gallons (231 cubic inches).
Grammes × 15.432 = grains. (Act Congress.)
Grammes × 981 = dynes.
Grammes (water) ÷ 29.57 = fluid ounces.
Grammes ÷ 28.35 = ounces avoirdupois.
Grammes per cu. cent. ÷ 27.7 = lbs. per cu. in.
Joule × .7373 = foot pounds.
Kilograms × 2.2046 = pounds.
Kilograms × 35.3 = ounces avoirdupois.
Kilograms ÷ 1102.3 = tons (2,000 lbs.).
Kilograms per sq. cent. × 14.223 = lbs. per sq. in.
Kilogrammeters × 7.233 = foot pounds.
Kilograms per meter × .672 = pounds per square foot.
Kilograms per cubic meter × .062 = pounds per cu. ft.
Kilograms per cheval vapeur × 2.235 = lbs. per HP.
Kilo-watts × 1.34 = horse power.
Watts ÷ 746 = horse power.
Watts ÷ .7373 = foot pounds per second.
Calorie × 3.968 = B. T. U.
Cheval vapeur × .9863 = horse power.
(Centigrade × 1.8) + 32 = degrees Fahrenheit.
Francs × .193 = dollars.
Gravity, Paris = 980.94 centimeters per second.

Dr. Snaitken says: It is well known that the Moors are inveterate coffee drinkers, especially the merchants, who sit in their bazars and drink coffee continually during the day. It has been noticed that almost invariably when these coffee drinkers reach the age of forty or forty-five their eyesight begins to fail, and by the time they get to be fifty years old they become blind. One is forcibly impressed by the number of blind men that are seen about the streets of the city of Fez, the capital of Morocco. It is invariably attributed to the excessive use of coffee.

SELECTED FORMULÆ.

Stereotypers' Paste.—Mix together with the hands until all lumps are dissolved six and one-half pounds Oswego starch and two and one-half pounds wheat flour in six gallons of water. Then add twelve ounces of common glue which has been previously dissolved in two quarts of water and two ounces powdered alum. Cook until the mixture boils thick. When cold take out a quantity sufficient for the day's use and add one-half its bulk of pulverized whiting. The whiting should be thoroughly incorporated with the paste, and the resultant mass forced through a sieve having about twenty meshes to the inch. The whiting should be freed from grit.—Paper Digest.

"Pole" Paper.—What is called "pole" paper is paper saturated with a substance that is sensitive to the action of the electric current, and that permits of instantly distinguishing the positive from the negative pole in an open circuit. According to the Annales de Chimie Analytique, this paper is prepared as follows: From 1 to 2 grammes of phthalein of phenol are dissolved in 10 cubic centimeters of 90 deg. alcohol. The solution is poured into a glass vessel, and about 110 cubic centimeters of distilled water are added to it. The result is a milky emulsion of phthalein. On another hand, 20 grammes of sulphate of soda are dissolved in about 100 cubic centimeters of distilled water. The first solution is poured into a porcelain tray, and several sheets of slightly porous paper are dipped into it one after another. These sheets, after being allowed to drain, are immersed, while still damp, in soda solution. The paper, after being dried, is extremely sensitive to the action of the electric current. In order to ascertain the direction of a current, a piece of the paper is damped, and the extremities of the two copper conductors are applied to it in such a way as to leave a space of about ¼ inch or 1 inch between them. One of the wires instantly produces upon the paper a deep red line, which is due to the action of the soda set at liberty, and which extends toward the negative pole upon the phthalein. The other wire remains inactive.

Domestic Ammonia for Cleaning Purposes.—Rub up soap and borax with water until dissolved, strain and add the other ingredients. The perfume may be varied to suit the price.

(1.)	Soft soap	1	ounce
	Borax	2	drachms
	Eau de cologne	½	ounce
	Stronger water of ammonia	5½	"
	Water, enough to make	12	"
(2.)	Sodium carbonate	20	"
	Water of ammonia	48	"
	Water	32	"

Mix. Allow to stand two or three days, and then decant the clear solution and bottle.

(3.) Here is a formula which yields a cloudy preparation:

Potassium carbonate	1	part
Borax	1	"
Green soap	1½	"
Stronger water of ammonia	4	"
Distilled water	8	"

Heat the water and dissolve in it the soap and potassium carbonate; then add the borax, and, when cold, the stronger water of ammonia. If a cheap odor is desired, the preparation may be perfumed with oil of mirbane.—Pharmaceutical Era.

Florida Water.—In general character Florida water resembles typical cologne water, the fundamental odor being derived from the orange family, and, like the latter, its composition varies greatly.

Oil of lavender	2	ounces
Oil of lemon	1	"
Oil of orange peel	1	"
Oil of cloves	5	drachms
Deodorized alcohol	1	gallon

Oil of bergamot	5	ounces
Oil of lemon	3	"
Oil of orange peel	2	"
Oil of lavender	3½	"
Oil of cloves	½	"
Oil of cinnamon	½	"
Oil of neroli	½	"
Alcohol	4	gallons
Water	1	"

We doubt whether the neroli in this would be a sufficient quantity to materially modify the odor, and it would add considerably to the expense.

Oil of bergamot	8	ounces
Oil of orange peel	4	"
Oil of lavender	3	"
Oil of cloves	1½	"
Oil of cinnamon, true	¼	"
Tincture of orris root (1 to 4)	½	pint
Tincture of Peru balsam (1 to 8)	¼	"
Alcohol	4	gallons
Water	6	pints

Oil of bergamot	3	ounces
Oil of lavender	1	"
Oil of cloves	1¼	drachms
Oil of cinnamon, best	2½	"
Oil of neroli	½	"
Oil of lemon	1	ounce
Essence of jasmine	6	"
Tincture of musk	2	"
Rose water	1	pint
Deodorized alcohol	1	gallon

If the mixture is cloudy, filter through a little magnesium carbonate.

While the operator should, of course, be careful to look to the quality of his materials, it is especially needful in employing oil of orange peel to have it fresh. After this oil has been exposed to the air for a comparatively short time it becomes worthless as a perfume or flavoring material; and the same is true as to oils of lemon and bergamot, excepting that the change occurs less rapidly with the former, and still less so with the latter. These oils, especially those of orange and lemon, should, on opening the original packages, be filled into bottles of such size that the entire contents of one may be used at one operation, and these, of course, must be kept tightly corked, and preferably in a cool, dark place.—Druggists' Circular

ENGINEERING NOTES.

There were 6,934 miles of railway in operation throughout the Mexican Republic on April 1 last.

In 1895 the British railroads carried 929,770,909 passengers, exclusive of commuters, an increase of 18,500,000 over the previous year. There were 1,024 persons killed, of whom 83 were passengers, and 4,021 wounded. The proportion of passengers killed to those carried is one in 11,000,000, and that of passengers wounded one in 840,000.

Expressed in terms of hundreds of square miles, of the leading railway countries Belgium has 29·1 miles of road per 100; Great Britain, 16·6 miles; Netherlands, 13·5 miles; Germany, 13·6; Switzerland, 13·1; France, 11·5; Italy, 7·8; United States, 5·7; Canada, 0·4; Mexico, 0·7; British India, 0·9; Argentine Republic, 0·7; and Australia, 0·6.

The largest floating dock yet built is to be located at Olongapo, in the Philippine Islands, the contract for the work having been recently awarded by the Spanish government to Messrs. R. Stephenson & Company, Limited, Newcastle-on-Tyne. The length of the proposed dock is 450 ft., width over pontoons, 117 ft., and depth to the top of side walls or girders, 38 ft. 6 in. The dock will be capable of lifting 12,000 tons, and can at need accommodate vessels 500 ft. long.

A sandblast apparatus was experimented with on March 2, in removing the paint from the hull of the United States cruiser Atlanta, with the result of doing the work with much greater rapidity than on the first trial, and it will now be used to clean the whole of the hull. A similar experiment was made two days later on the columns of the viaduct at One Hundred and Fifty-fifth Street, New York City, which were erected in 1890 and which now need repainting. A number of well-known members of the American Society of Civil Engineers were present, including Messrs. E. P. North, water purveyor of New York; Charles Macdonald, L. L. Buck and W. B. Parsons. The removal of the paint and scale, exposing the clean iron surface, was most thorough, the rate of removal being about one square foot in two minutes, says Engineering News.

A deeper entrance to New York harbor is recommended by Col. G. L. Gillespie, Engineer Corps, U. S. A., in a late report to the Secretary of War upon the need and cost of a 35 ft. channel at low water. There has been since 1891 a continuous waterway, from the Narrows to the Atlantic, 1,000 ft. wide and 30 ft. deep at mean low water, as provided for in the River and Harbor Act of 1884. But the average draught and tonnage of steamers coming to this port have progressively increased within the last six years; and the average draught of outgoing loaded steamers is now 27 ft. The draught of some of the larger vessels has reached 30½ ft. on their outward passage. As these vessels should have 2 ft. to 3 ft. of water under their keels, a depth of 35 ft. is urgently needed, and the improved channel should be wider than 1,000 ft., owing to the increased length of steamers. The estimated cost for deepening and enlarging the channel to widths of 1,000 ft., 1,500 ft. and 2,000 ft. is given as $1,740,000, $2,772,000 and $4,180,000 respectively, all to be 35 ft. deep at mean low water.

In an old pamphlet which was discovered recently in the Astor Library in New York are some figures with reference to the cost of a piece of track laid by the Baltimore and Ohio in 1830 and 1831. I. L. Sullivan, evidently a civil engineer, in a report to R. L. Colt, estimates that the track laid with wood sleepers, wood bearers and plate rail, exclusive of ground and gradation, would cost $4,362 per mile; with stone blocks, wood bearers and plate rail, of which the cost of iron was $1,324, the cost would be $5,115 per mile; with granite sills in line with plate rail, of which the iron was $2,037, the cost would be $6,500 per mile, divided as follows: Sills at $11.50 per 100, $3,680; bar iron, $1,300; broken stone, $640; various items, $880. This engineer speculated on two ton loads and one ton cars, and said in his report that the Baltimore and Ohio would be doing a very rash thing if they went beyond this point. He also says: "The locomotive engine now operating successfully on the Baltimore road, made by Mr. Winans to run on a friction carriage, though of moderate power, has a great useful effect." Mr. Winans was apparently the first to patent outside journals and to reduce the resistance from friction from 11¾ to 4 pounds per ton. On July 4, 1828, Charles Carroll, of Carrollton, the celebrated signer of the Declaration of Independence, laid the first stone on the Baltimore and Ohio Railroad.—Railway World.

Active and organized efforts are about to be made to obtain from many of the State legislatures of the United States laws requiring stationary engineers and those in responsible charge of steam boilers and steam machinery, which by incompetent management may endanger the public, to be examined and licensed. Such laws are now in force in three of the States—Massachusetts, Minnesota and Montana. The engineers of New York and Connecticut have just held State conventions, adopted a form of law and arranged for its presentation to their legislatures. Maine, New Hampshire and Rhode Island already have the subject under consideration, and movements are being made in the same direction in some of the Western States. The bill which has been adopted by the New York and Connecticut engineers makes it unlawful to employ any person or for any person to serve as engineer or attendant upon a steam boiler or steam engine in operation who has not been examined with reference to his ability to handle that particular plant, and given a certificate to that effect. Any man who can show the inspector that he is a safe person to be in charge of the plant he desires to run, can have a license. In order to learn the feeling of the Massachusetts manufacturers toward the law, which has now been in force some two years in that State, a thousand letters were sent among the manufacturers of Massachusetts asking if the law had been in any way inimical to their interests, and if the manufacturers of other States have anything to fear from the passage of similar measures. The responses, says Power, are almost unanimous in their approval of the measure, and many representatives of large manufacturing interests declare that the manufacturer is one of the largest beneficiaries under the law.

ELECTRICAL NOTES.

A Brunswick firm has secured a concession to put down a plant to utilize the water power of the Iron Gate Falls on the Danube.

The government of Sweden has instructed the state telephone authorities to put aside a handsome sum for prizes for useful inventions in this branch made within Sweden.

The Electrical Engineer states that the Diatto surface contact electric tramway is to be tried at once at Tours. At present the tramways there are run with Serpollet steam tramcars.

The latest application of the X ray is the analyses of coals by means of the fluoroscope. It is said that the density of the shadow of a coal sample viewed through this instrument is dependent upon the percentage of ash, and by watching the shadow of the sample under investigation with that of a sample of coal of similar size and thickness, and with a known percentage of ash, speedy and possibly fairly accurate results may be obtained.

"**A novel** use of X rays is reported in England. A lady, while baking some cakes, lost her ring in the paste, but did not discover her loss until the cakes were out of the oven. Afraid of choking some member of her family, she struck on the happy expedient of taking the cakes to a chemist and photographer who placed them under the X rays, with the result that the ring was immediately located and removed." The above is only a specimen of the newspaper items which are published almost daily concerning the X rays. It is one of the worst which the unfortunate X rays have had to shoulder.

Experiments have recently been carried out between Paris and Marseilles by the Chemin de Fer de l'Ouest Company with the new Chapsal electric air brake. The brake has been designed to overcome the difficulties and delays attending the use of the ordinary air or vacuum continuous air brake, and is intended principally for use on freight trains, where the impulse takes so long to travel from end to end when applied in the usual way. An electric apparatus is used in connection with the Chapsal brake which, it is said, starts the braking pistons directly it is set in action.

A leading export house interested in Japanese trade was informed recently that the following street railways were about to complete organization with an aggregate capital of about $3,500,000: The Fushimi Electric Railway, promoted by Okubo Yoskio, of Tokio, will construct a line 28½ miles long, running from Fushimi to Nishinomiya. Another line, 5⅛ miles long, between Inamimachi and Demachi. The Tokio Circuit Tramway will build a line 44⅓ miles long in Tokio. All these lines will require, the exporters claim, the necessary materials and rolling stock. American manufacturers will have as much of an opportunity to furnish it as their foreign competitors.

The first sawmill operated by electric power in the United States, and probably in the world, is said to be that of the American River Land and Lumber Company, which is located close to the power house at Folsom, Cal., of the Folsom-Sacramento power transmission. This was started successfully last December, and is cutting 50,000 feet of lumber per day. The current is three-phase, taken from the power house at Folsom, and the motors are all of the induction type, the installation having been made by the General Electric Company. The motors employed are one of 75 horse power, one of 50 horse power, both running at 720 volts, three of 30 horse power, and one of 5 horse power, operating at 200 volts.

In his annual report on the work of the Philadelphia Electrical Bureau, Chief Walker gives some interesting figures. Philadelphia, with 129 square miles, is equipped with 885 fire boxes, 56 of which are indoors, paid for by private individuals. New York, with but 31 square miles, has 2,500, and Chicago between 2,500 and 3,000. To thoroughly equip the city they should have at least 2,500 signal stations. The average price per arc lamp per night for 1895 was 41·15 cents; for 1896, 35·05, and proposals for 1897 show 33·3 cents, a reduction of $42,862.25. While the number 6,228 now provided for seems to be large, yet, when the great number of streets yet to be lighted is considered, it becomes insignificant. During the year there have been laid 221,834 feet of conduit by the city, says the Electrical Engineer.

A 60 mile electric railway, to be operated by alternating current, is projected to connect the cities of Detroit and Port Huron, Mich. The line will be single track, with turnouts, following the western bank of the St. Clair and Detroit rivers and the shore of Lake St. Clair. It will carry both freight and passengers. Two-car trains will be run, consisting of a 33⅓ ton motor car and a 15 ton trail car. There is to be but one generating plant on the line, about 20 miles from Detroit, at a point which will be about the center of load distribution. Three phase current will be generated at this station, which will be converted by rotary transformers placed at four substations along the line, from which direct current will be delivered into the feeder circuits. Mr. John D. Dyar, of Detroit, is to be the builder and Mr. Charles G. Armstrong, of Chicago, is the consulting electrical engineer.

For the purpose of shunting cars at New Haven from the main line along the road which appears to be the joint property of a number of manufacturers, an electric locomotive has replaced horses. The road is only two miles long, and the General Electric Company have furnished for this purpose a 30 ton locomotive, and this has been at work since December 11 last. The drawpull is 7,000 pounds. There are four wheels of 44 inches diameter. The voltage is 500 and the current 600 amperes at full and 300 at half speed, with normal drawbar pull. The overall dimensions are 16 feet 6 inches × 11 feet 6 inches × 8 feet 3 inches, and the wheel base 5 feet 6 inches. There is a motor to each axle. They are gearless and supported on spiral springs. The trolley system is worked. The armatures are of ironclad type and are wound on a sleeve through which the axle passes, motion being communicated by projecting arms and a plate to form a flexible coupling. The usual fittings are provided.

MISCELLANEOUS NOTES.

A medicine glass has been invented with a partition in the middle, by means of which disagreeable tasting medicine is separated from some flavored liquid or wine which bathes the lips and mouth before the dose is swallowed.

The percentage of alcohol in various liquors is: Scotch whisky, 54·53; Irish whisky, 53·9; rum, 54·68; gin, 51·6; brandy, 52·39; Burgundy, 14·57; Cape Muscat, 18·25; champagne (still), 13·80; champagne (sparkling), 12·61; cider, 5·2 to 9·8; Constantia, 19·75; gooseberry wine, 11·48; currant wine, 20·50; port, 22·90; Madeira, 22·27; Teneriffe, 19·79; sherry, 19·17; claret, 15·1; elder, 8·79; ale, 6·87; porter, 4·2; Malaga, 17·26; Rhenish, 12·8; small beer, 1·28.

La Sucrerie Indigene says that in many portions of Italy they have been experimenting in beet culture during the last three or four years. An association has been organized among the farmers to promote this industry. The attitude of the government toward this business is a matter of serious concern, and it is thought that but little can be done until this matter is more definitely settled than now. A large sugar factory has been built at Ravenna.

Professor Silvanus Thompson says that, although Bavaria, measured by the number of its inhabitants, was only a little larger than London, yet it contained three universities, and supplied more than $500,000 a year for their support, while Würzburg, the small Bavarian town in which Professor Roentgen carried on his experiments, had at its university a laboratory which was more than a hundred times better equipped for scientific research than that of the University of London.

The growth of Japanese imports and the shrinkage of exports have had the effect of reversing the usual relative positions of Great Britain and the United States. The share taken by the latter in Japan's foreign trade for the half year is only one-seventh, while that of Great Britain amounts to nearly one-quarter, and that of the British empire to over 46 per cent. of the whole. The British Indian imports have risen from $12,001,810, for the whole of 1895, to $13,161,409 for the first half of 1896.

Aluminum yacht blocks have been tried in service for over a year, and have given very satisfactory results. These blocks stand the strain very well and save considerable weight in blocks used aloft, where lightness is a great desideratum. In actual tests aluminum blocks have shown remarkable strength; a block weighing about three ounces has stood a test of 700 pounds, and one weighing eight ounces a test of 1,000 pounds; while an eighteen ounce block has stood a strain of 1,600 pounds.

No one is surprised to find a worm in an apple, and occasionally in other fruits, but it is a surprise to learn that the orange is getting to be infested as well as the rest, says Mehan's Monthly. The worm in the orange is named by the entomologist Trypeta ludens. So far as has been discovered, it has not been found in any of the oranges grown in the different parts of the United States, although it is said it is getting quite common in the fruit grown beyond our Mexican borders. In the Florida Farmer it is reported that the worms have been found in oranges grown in New Mexico.

The plans for the new United States Mint, to be built in Philadelphia, at Sixteenth and Spring Garden Streets, have been completed and approved, and advertisements for bids for the erection will be promptly issued, says the American Manufacturer. The act authorizing the building fixes the cost at $2,000,000. The site cost $325,000. The plans propose a building to cost $1,650,000. It will occupy the entire square bounded by Spring Garden, Sixteenth, Buttonwood and Seventeenth Streets. The main front is on Spring Garden Street, and the side entrance for workmen and wagons on Sixteenth.

The St. Petersburg Ministry of Finance has just published a report on the output of platinum in Russia, whence the world derives by far the greater portion of its supplies of that rare and indispensable metal. Four times as much platinum is won in Russia as in all other lands put together. In 1880 the output was 2,946 kilogrammes; in 1894 it reached 5,208 kilos.; and in 1895 it fell to 4,413. Meanwhile the demand increased greatly; and the metal appreciated to such an extent that in the raw state it commanded £45 a kilo. in Russia. Platinum is found only in the southern Urals. Its manufacture is unknown in Russia. The smelting, refining, and working are done mainly in Germany, whence Russia imports all the manufactured platinum she requires. Associated with platinum is the still rarer metal iridium, but only in small quantities, the total output of iridium in 1895 having been 4·1 kilos. Having regard to the slowness with which the output of platinum increases, and to the rapidity with which the demand grows, it is rather surprising that the price is not higher than it is. The Russian government once tried the experiment of issuing a platinum coinage, but the effort to keep it in circulation was unsuccessful.

In England the Great Western and the Midland Railways offer sums of money annually to encourage platform gardens, says the Quarterly Review. In the case of the former company a regular system has been in operation for eighteen years, £250 being voted annually for the purpose. The line is divided into twelve sections. To each a special prize of £5 is awarded, and there are 165 ordinary prizes, ranging from £3 to 10s., a list of the successful stations being published each year. A circular is also sent round furnishing a complete list of plants suitable for various purposes—for permanent borders, for summer bedding, for mixed borders of hardy plants, for spring bedding, as well as a list of evergreens and creepers, together with particulars as to height, color, dates for sowing and many other necessary hints. The Midland Railway devotes £200 in the same way, the prizes ranging from £7 10s. to 5s. A fully qualified inspector, whose duties take him to every part of the line, is deputed to deal with the matter, and the whole scheme is pronounced a success. The Great Northern and the London and Northwestern Companies let allotments to their men where possible, the number of allotments in the case of the former company reaching very nearly 2,500.

TRANSMISSION OF MOTION IN BICYCLES.

Transmission of motion in bicycles, as well known, is generally effected through an endless chain—a flat or a roller one. The most important improvement in this part made this year is the Simpson lever chain. The links in this are flat, but of triangular shape. They are united at the base by small cylinders that engage with the teeth of the sprocket of the crank hanger, while they slide over the even surface of the groove of the rear sprocket. But the apices of the triangular links engage, through their rollers, with teeth situated at the periphery of the sprocket. In the Immer-clean system, instead of modifying the chain, one has transformed the sprockets, which, instead of having a felly formed of a single cylindrical surface, present a succession of inclined planes forming a knife, so as to facilitate the running off of mud.

A NEW CHAINLESS BICYCLE.

The transmission of the motion of the pedals through a chain has more than one drawback, and an effort has been made to substitute different systems of gear wheels for it. This year few combinations, which are quite happy from a mechanical standpoint, have been brought out. The "Cyclit," for example, which we figure herewith, is a chainless bicycle in which the hind wheel is the driver. The gear mechanism consists of two rings mounted upon independent axles revolving in ball bearing boxes, at which, on each side of the wheel, end the extremities of the forks that constitute the frame. These ball bearing boxes are provided behind with strong disks connected by a rod that serves as a fixed axle upon which the driving wheel revolves. The gear rings carry internally toothed wheels each of which meshes with a pinion keyed at the extremity of the hub of the rear wheel. The advantage is thus obtained of having a very strong internal gearing and a frame that never has any tendency to get out of true, like that of machines that are driven from one side. This machine is much shorter than others. As the crank hanger is arranged on the two sides of the same wheel, the fork is not loaded, and the machine is wonderfully well adapted for making sharp curves.

In the Dechamps bicycle the entire movement is at an equal distance from the cranks. It follows from this that the pressures and the work of the machine are equally distributed. All the parts of the gearing are easily got at for the purpose of lubricating, cleaning, etc. The delicate parts are protected from dust, since the differential motion, which is quite ingenious, is inclosed in a tight box.

In the Elan bicycle the pedals no longer effect a complete circular motion, but describe a small arc of a circle of wide radius. It is, in reality, with levers that the pedaling is done almost vertically.—La Science en Famille.

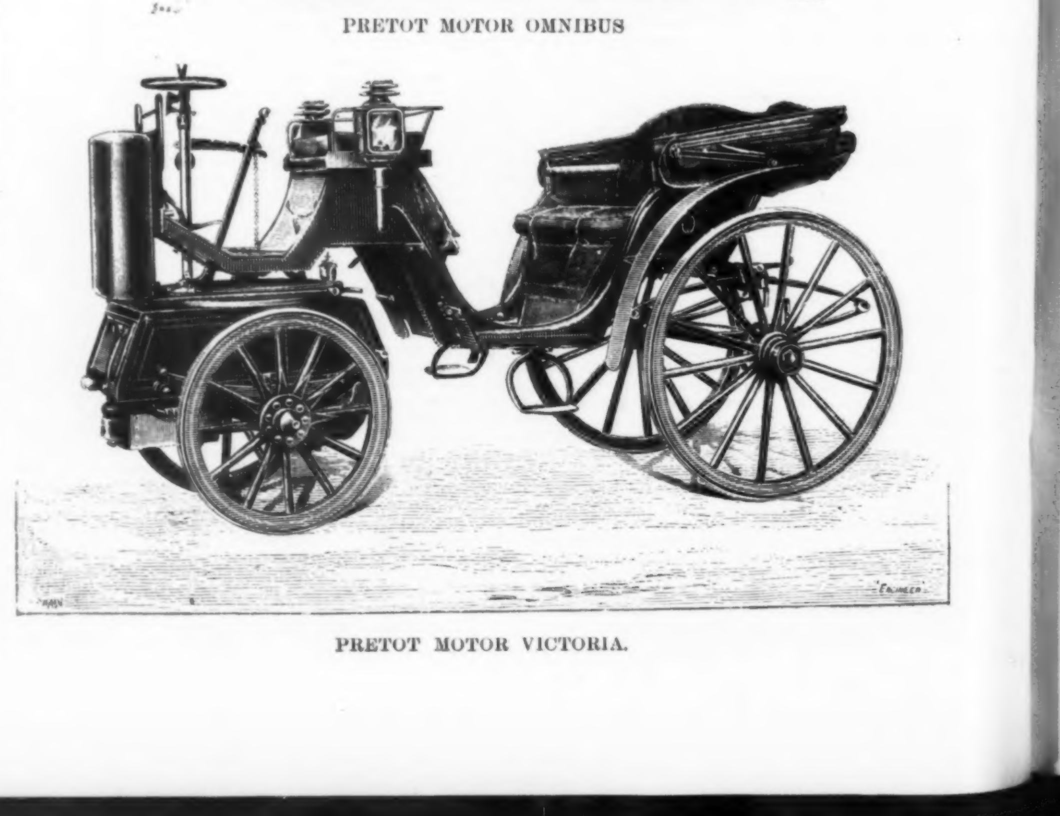
THE PRETOT MOTOR CARRIAGE.

The requirements of the Paris cab companies for a mechanism that may be easily fitted to vehicles without the necessity of altering the form of the carriage in any way have induced engineers to give attention to a new type of propelling machinery. The first and apparently the most successful of these applications, says Engineer, is the petroleum motor of M. Pretot, 42 and 46 Avenue Philippe-Auguste, Paris, which attracted a great deal of notice at the late Salon du Cycle, on account of its novelty and ingenuity. M. Pretot takes an ordinary carriage, removes the shafts and fore wheels, and fixes a circular plate under the footboard. This plate carries small wheels or casters revolving on a ring of the same diameter as the plate, and bolted on to the fore carriage containing the machinery. We are informed that the employment of casters for reducing friction between the upper plate and fore carriage is merely a temporary device, and will be improved upon in future vehicles. The spindle for steering carries a pinion at the lower end which fits into the teeth inside the ring, so that the whole of the fore carriage is turned. By this arrangement it is claimed that the vehicle may be turned round in a remarkably small radius.

The mechanism is extremely simple, consisting of a single cylinder horizontal motor, a petroleum reservoir, a carburetor, and a cylinder for the exhaust. The whole of the machinery is carried by the front axle and wheels which form part and parcel of the fore carriage. Running at about 700 revolutions a minute, the motor develops 5 horse power, and is very carefully balanced in order to reduce the vibration to the smallest possible limit. It is geared on to the intermediate axle by pinions, and thence to the driving wheels by chains, but it is intended to entirely suppress the chain, so as to do away with the noise of running. One feature of this arrangement is that the front wheels are utilized as driving wheels, thus giving to the power a tractive instead of a pushing action, and utilizing it to much better advantage than in cases where the carriage is propelled from the rear. In fact, the mechanism has been designed to exert power in very much the same way as is done by the horse, and the same idea is seen in the design of the driving gear, which is intended to facilitate the management of the vehicle by inexperienced men. A single lever is used for this purpose, and, in pushing it forward, the rate of traveling may be regulated at six speeds up to 20 kiloms. an hour, or even more if desired. In drawing the lever back the speed is reduced in like proportion until the carriage comes to a standstill, and on reaching the limit of the pull the mechanism is reversed to a speed of about 4 kiloms. an hour.

The motor is placed at one side of the fore carriage, and the petroleum reservoir at the other, the latter containing enough spirit to run for about 60 kiloms. Another supply in reserve may be carried under the driver's seat. The carburetor is of the usual type, placed low down, so that there seems to be little liability to accident from a communication of the vapor with the firing tube. If required, the explosive mixture is fired by electricity. Underneath the fore carriage is the cylinder, into which the exhaust passes for expansion before escaping into the air. The noise is thus stifled, and there is no discharge of visible vapor. The whole mechanism is contained in a case about 42 in. long and 24 in. broad, and is thoroughly protected from dust and mud. A sliding panel in front exposes the whole of the mechanism, which can be cleaned or repaired without difficulty. The weight of the machinery is 450 kilos. The cooling water is carried in a reservoir in front of the splashboard, where it is exposed to the air, and it will keep the cylinder cool for a considerable time without renewing. Even when standing still there is remarkably little vibration, and it is confined almost entirely to the fore carriage, but even on the driver's seat there is not enough to cause the slightest inconvenience. When running the vibration is, of course, still less perceptible. Like all explosive motors, there is rather more noise than is pleasant, but we are assured that this will be overcome by improvements that are now being carried out in the system. M. Pretot has a considerable number of orders in hand for his new mechanism, and it is being experimented with at the present moment by the Paris cab companies.

PRETOT MOTOR OMNIBUS

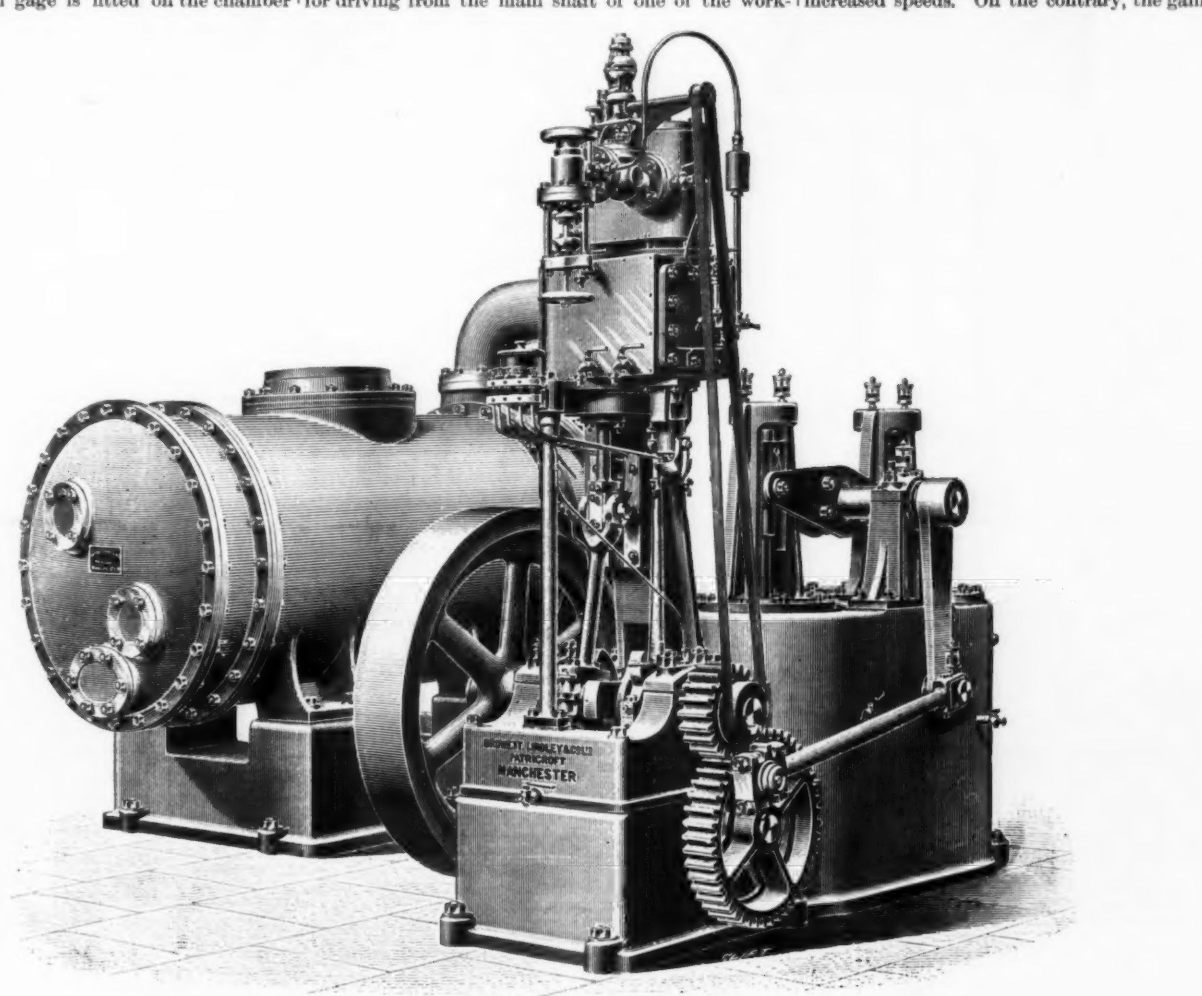


PRETOT MOTOR VICTORIA.

INDEPENDENT SURFACE CONDENSING PLANT.

The accompanying illustration is taken from a photograph of one of the standard types of independent surface condensing plants manufactured by Messrs Browett, Lindley & Company, Limited, of Patricroft, near Manchester England. The identical plant from which the photograph is taken was constructed for the Croydon Electric Light Station. This plant is constructed to condense 11,000 gallons of steam per hour and has a tube surface of 800 square feet. As will be seen from the illustration, a pair of vertical single acting air and circulating pumps are mounted in a cast iron casting, which has an extension to carry the engine. The buckets are worked by links attached to an overhead pump mounted on a substantial rocking shaft and supported on bearings between the pumps. This rocking shaft has at one end a lever connected by a rod to a crank pin, which is mounted on a spur wheel driven by a pinion from the engine shaft, the second motion shaft on which the spur wheel is fixed being carried in two journals formed at the back of the engine base. The surface condenser, which is

supported on two feet, and placed alongside the pumping plants, has branches connected respectively to the exhaust steam main and a branch for the circulating water discharge. The engine is one of Messrs Browett, Lindley & Company's patent tandem compound electric lighting engines, fitted with steel crank shaft 3¼ in. diameter, flywheels, stop valves, splash guards, and other usual fittings; continuous lubricating arrangement for long runs. An Acme governor is fitted to prevent the plant racing in case of any failure. The engine cylinders are 5½ in. and 9½ in. diameter by 8 in. stroke, and the ordinary speed is 200 revolutions per minute; but the speed can be regulated by the stop valve to run at any required speed, according to the duty required at any time of the day—slowly for the day load and full speed for the full night load. Both the pumps are single acting. The air pump is 10 in. diameter, with 10 in. stroke, and the circulating pump 19 in. diameter and 10 in. stroke. The exhaust branch is 12 in. diameter and the circulating water suction and discharge 9 in. The pump barrels are of gun metal, and are constructed with flanges at the top, and are secured in the main cast iron casing by "Delta" metal screws, which are readily accessible when the top covers of the pumps are removed, so that in case of damage they can be easily removed and taken away for reboring or repairs. The vertical position of the pumps, however, reduces wear and tear to a minimum, and insures a high efficiency, with corresponding high and steady vacuum. The pump buckets are also of gun metal, with large parts for the discharge of water and air, and are fitted with India rubber valves and brass guards. A foot valve is attached to the air pump. A 12 in. dial vacuum gage is fitted on the chamber in a convenient position, and there is also a rod and key for emptying the water spaces, and mud doors are provided for cleaning out the inside of the chambers. The tubes in the condenser are of solid drawn brass, ¾ in. bore, secured into Muntz metal tube plates at each end by screwed glands or ferrules, with cotton tube packing, the ferrules at one end of each tube being provided with an internal collar to prevent movement in the plate and the other end being free to allow of expansion or contraction with changes of temperature. Many of these plants, ranging in power from 200 to 1,000 h. p., are in use both as jet and surface condensers. For the jet type the circulating pump is of course not required, and the two pumps become balanced air pumps of equal capacity. The advantages the makers claim for these plants are accessibility to all parts, and, not least, that the plants consist of ordinary well known and well tried parts, such as any engineer can examine, adjust, or repair. We are indebted to the Steamship, of London, for the cut and copy.



INDEPENDENT SURFACE CONDENSING PLANT.

ROPE DRIVING.*

By ABRAM COMBE.

INTRODUCTION OF ROPE DRIVING.—So much has been said and written on the advantages and application of rope driving, and so many data and formulæ have been published from time to time, that it is hardly necessary to add to the information already available in these respects; but as rope driving emanated from Belfast, and has now grown to such large proportions in the industrial transmission of mechanical power, a short history of its origin, introduction and development may prove of interest on the present occasion. Its introduction is due to the late Mr. James Combe, who in 1856 applied an expanding pulley with V-shaped sides to the differential motion of flax and tow roving frames. The expanding pulley was driven by a round leather rope from a driving pulley grooved with a V-shaped groove. In the course of his experiments in perfecting this motion he was struck by the large amount of power obtained from round ropes working in V-shaped grooves; and this led him to try their application to the transmission of larger powers. With a view of arriving at the most effective angle for the grooves, a series of experiments were made in the Falls Foundry works in the following manner. A pulley, fixed from revolving, was made with a number of grooves, each having its sides sloping at a slightly different angle from the others; ropes were then laid over these grooves with weights hanging from them at one end and counterbalance weights at the other; and the effect produced on the biting power of the rope in the groove by increasing and diminishing the weights and the counterbalance weights was carefully noted. The object was to determine in a practical manner the most suitable angle of groove for a driving rope, so that the rope should neither slip nor yet bite too much into the groove; and the angle chosen after the above simple experiments, namely, 45 degrees, was adopted in the first pulleys set to work, and is at present generally used for rope driving under ordinary conditions.

After several years' use of grooved pulleys and ropes for driving from the main shaft of one of the workshops at the Falls Foundry to that of another, the advantages of rope driving under certain conditions were found to be so great that, on the occasion of replacing one of the main engines in the beginning of 1863, rope driving was adopted for transmitting the entire power of the engine, amounting to over 200 horse power, from the second motion shaft to the principal shaft. This is the first instance of rope driving being used for a main drive of such importance, and the original pulleys are still in existence and working daily.

Materials of Ropes.—About that date round ropes made of leather strips were generally used. These, however, were found to have the objection that they were liable to untwist, and the ends of the leather strips were apt to fly out during the working and cause trouble. Moreover, the strips of leather being cut out of the hide in a spiral, were less strong where cut from the smaller diameters, and were liable to break at those parts. Manila ropes were then tried with good results, and leather ropes gradually gave place to ropes made from manila.

Relative Diameters of Ropes and Pulleys.—It was early recognized by the late Mr. James Combe that it is necessary to proportion properly the diameter of the ropes to the diameter of the pulleys on which they work; and he adopted the following minimum diameters of pulleys for the various sizes of ropes:

1¼	in. diameter rope,	3	ft. diameter pulley;	ratio	1 to	28·8
1½	" "	4	" "	"	1 "	32·0
1¾	" "	5	" "	"	1 "	34·3
2	" "	6	" "	"	1 "	36·0

Experience has shown that the results have not been so satisfactory when ropes of above sizes have been used on pulleys smaller than the above minimum diameters.

Power Transmitted.—When working under ordinary conditions, the following simple bases were taken from which to calculate the power that each of the foregoing sizes of rope would transmit for each 100 revolutions per minute made by the pulley upon which it is working:

Rope	1¼	in. diameter on a	3	ft. pulley	5 I. H. P.
"	1½	" " "	4	" "	8 "
"	1¾	" " "	5	" "	11 "
"	2	" " "	6	" "	15 "

And for other sizes of pulleys the power transmittted is calculated to be increased in direct proportion to the diameters of the pulleys. When working under the most advantageous conditions—for instance, where the ropes are running horizontally at good speeds, with the pulleys at a proper distance apart, and with the bottom rope acting as the driver—the above bases may be increased by 20 to 25 per cent. with safety. On the other hand, when the ropes are working under unfavorable conditions, with centers of pulleys too close together, or ropes running vertically, these bases must be diminished by 20 to 25 per cent. The exact amount of increase or decrease on these bases has to be determined in each individual instance, according to the circumstances under which the ropes are working.

Speed of Ropes.—The speed originally adopted as being the most advantageous was about 3,300 ft. per minute. This speed has since been far exceeded in many instances; but it is a question whether advantages have been reaped proportionate to the power gained by increased speeds. On the contrary, the gain of power by increased speed is largely counteracted by loss of power from atmospheric friction and from centrifugal action; and when this loss is taken into account, along with the increased wear and tear on the ropes and bearings, the speed originally adopted, and speeds within certain limits of it, have been found to give the best results.

Extended Form of Rope Driving.—The new method of driving soon became known to several English and Scotch engineers, who joined in its further introduction and development, and in July, 1864, a drive was started in the Hilden Mills of Messrs. William Barbour & Sons, Lisburn, from the second motion shaft to the various lines of shafts, and is transmitting 600 I. H. P. A rope drive from the flywheel of the engine itself was erected in 1873 at Owen O'Cork Mills, Belfast. This drive was designed by Messrs. Combe and Barbour, by whom also the pulleys were made, the flywheel being supplied to their instructions by Messrs. Hick, Hargreaves & Company.

Cotton Ropes.—Later on, in certain districts, especially those in which the cotton industry prevailed, cotton ropes began to be used. These have the advantage of being rather more pliable than manila ropes, especially when the latter are new. The relative merits of ropes made of manila and those made of cotton have frequently been discussed; but experience has shown that, if the pulleys are properly designed and applied, and if the ropes are the proper diameter, good results are obtained whether the ropes are made of manila or of cotton.

Shafts not Parallel.—One of the great benefits that was found in rope driving at a comparatively early stage was that ropes could be applied with advantage

* Abstract of paper read before the Belfast meeting of the Institution of Mechanical Engineers.—From the Practical Engineer.

to transmit power between shafts that were not parallel. In 1875 a drive was put up at the works of Messrs. Combe & Barbour to transmit 100 I. H. P. from one shaft to another which was not quite parallel with it. Here the angle between the shafts is about 3 degrees, and the ropes were applied without making any alteration in the form of the grooves. When, however, it is desired to employ ropes for driving shafts at a greater angle, the grooves in the pulleys are altered in section so as to allow the ropes to enter and leave the grooves without greater friction on their sides than when the shafts are parallel.

Endless Rope for Close Shafts.—In 1878 grooved pulleys and rope driving were introduced to replace pairs of large geared wheels, which from one cause or another were giving trouble; for example, in places where they were used to combine the power from a steam engine with that from a water wheel, or to combine the power from two engines working under slightly different circumstances. Here the centers of the wheels were so close together that ropes, if applied separately in the ordinary way, would have been too short for effective driving, and there would have been difficulty in putting equal tension upon each of the several ropes. Consequently, in order to secure a proper length of rope and equal tension, a single continuous rope was used, which was laced round and round the pair of pulleys, passing from the first groove of the driving pulley to the first of the driven, thence back to the second groove of the driving pulley, and on again to the second of the driven, and so on; and a tension pulley was added for leading the rope back from the last groove into the first.

Rope Flywheels.—The continued rapid extension of rope driving, and more especially of driving direct from the flywheel of the engine to the various shafts, led to designing flywheels to suit the high speeds. A method of construction designed by Mr. James Barbour in 1879 has the peculiar advantage that instead of depending solely on a cast iron arm for connecting each segment to the nave, a strong wrought iron bolt is used, which passes down through the middle of the tubular cast iron arm, and connects each segment directly with the nave. Consequently this bolt not only receives the tensile strain caused by centrifugal force while the wheel is in motion, but it also withstands the driving home of the cotters when the wheel is being put together. When cast iron alone is used for the arms, the driving home of cotters is a frequent source of breakage, which may not be detected until the flywheel gives way; whereas by driving the cotters into a long malleable iron bolt there is less danger of fracture. The starting worm or barring engine is made with three pawls for barring round, in order that the motion may be continuous instead of intermittent, as it is when only one or two pawls are used.

Crossed Ropes.—It was about the same date that driving by crossed and half crossed ropes was introduced; also that rope driving was applied to shafts working at right angles to each other, round corners, etc. The grooves are constructed so that their pitch is greater than twice the diameter of the rope, as a further means of preventing the ropes from rubbing against their neighbors.

Endless Rope with Loose Guide Pulleys.—In 1889 an arrangement of rope driving was introduced by Mr. James Barbour. Here the driving and the driven shafts were near together, and there was not sufficient space to apply the tension pulley previously described. A single continuous rope was therefore laced round the grooves of the pulleys, and for the purpose of leading the rope back from the last groove of the one pulley into the first groove of the other an additional single-grooved pulley was mounted loose on each shaft; these two loose pulleys were made larger in diameter than the fixed pulleys, and the rope was led from one to the other over the top of the ropes working in the grooves of the fixed pulleys. A large number of drives have been erected in this way, and all are working satisfactorily.

Endless Rope Driving Several Pulleys.—About the same date also a drive was erected in which a single continuous rope was used for driving from one common pulley several shafts running at different speeds. In this method a tension pulley is used to bring the rope back from the last groove into the first, and at the same time to take up the slack of the ropes. In 1890 Mr. Barbour further developed the use of the single continuous rope by applying it to the half-cross drive.

Substitution of Rope Driving for Geared Wheels, and Relative Amount of Power Absorbed.—In many instances existing gearing and upright shafts have been thrown out and replaced by rope driving; and where the rope driving has been properly designed and erected, the total power for the rope driving has in none of the installations which have come under the writer's observation exceeded that which was required when driving by wheel gearing; and in many cases the power required to drive the same amount of work by ropes has been less than it was before the change in method of driving took place.

The above examples of the transmission of mechanical power by ropes serve to illustrate the development of this method of driving. Numerous variations have, of course, been made upon each of these plans, which have largely extended the field for the application of rope driving; so that this method of driving, which arose from such a small origin, is now widely adopted for industrial purposes. There is also no doubt that other developments will take place in the future, which will further extend its sphere of usefulness.

The growth of textile industries in Japan continues apace. It is estimated that at the close of 1896 the number of spindles in Japan would exceed 1,000,000.

A NEW INVENTION FOR THE UTILIZATION OF WAVE POWER.

For many years past engineers have endeavored to devise a practical plan or apparatus whereby the actual power resulting from the action of waves and tides may be conserved, and the energy either utilized immediately or accumulated and stored for future usage. Granted that an efficient apparatus can be devised whereby even a tithe of the energy can be made available, it is obvious that the purposes to which it may be applied are many. In the designing of power generators, even those utilizing the energy of falling water, it is necessary, from a commercial point of view, that their efficiency should approximate with some amount of accuracy to the theoretical value of the source of power. In the designing of wave motors and tide motors, however, this relative efficiency can in some measure be ignored, for the power available is so vast that the successful utilization of even a small fraction of it would create an almost entirely new set of industrial and manufacturing conditions in those districts in which tide and wave power is available. Ultimately, of course, the inventor would strive to perfect his apparatus so that the results bore some close relation to the potential energy; at present, however, as we have said, he is untrammeled by such considerations, and his leading aim is to devise some means of making perhaps the greatest of nature's powers available for the use of man.

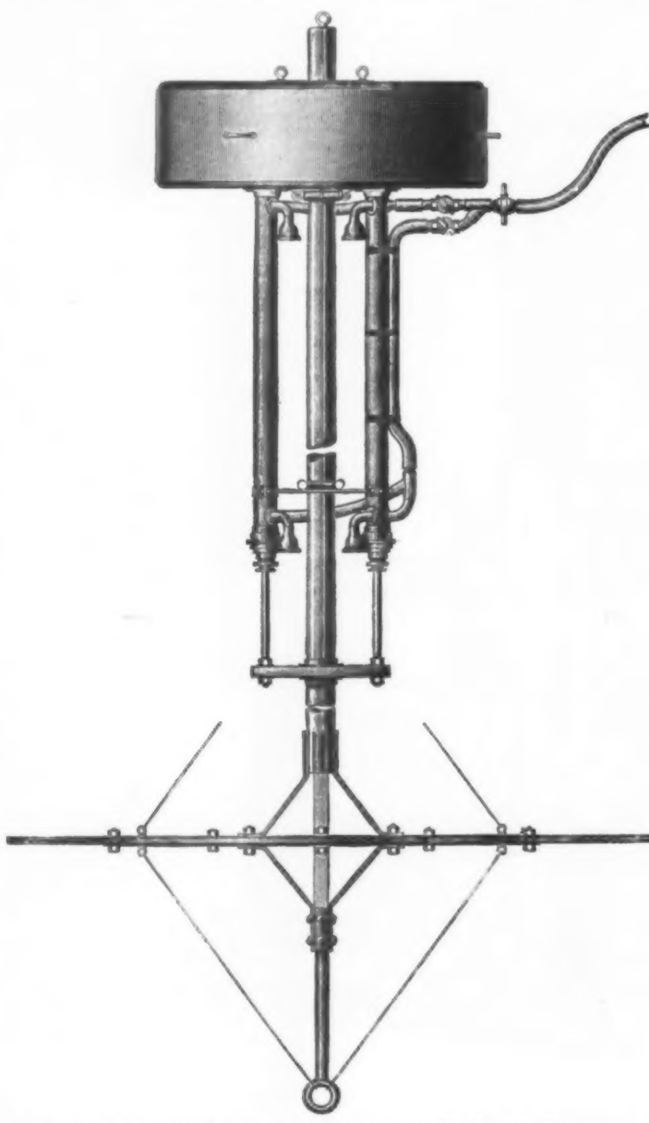


Fig. 1.—Experimental Apparatus Developing 3·7 H. P.—General View.

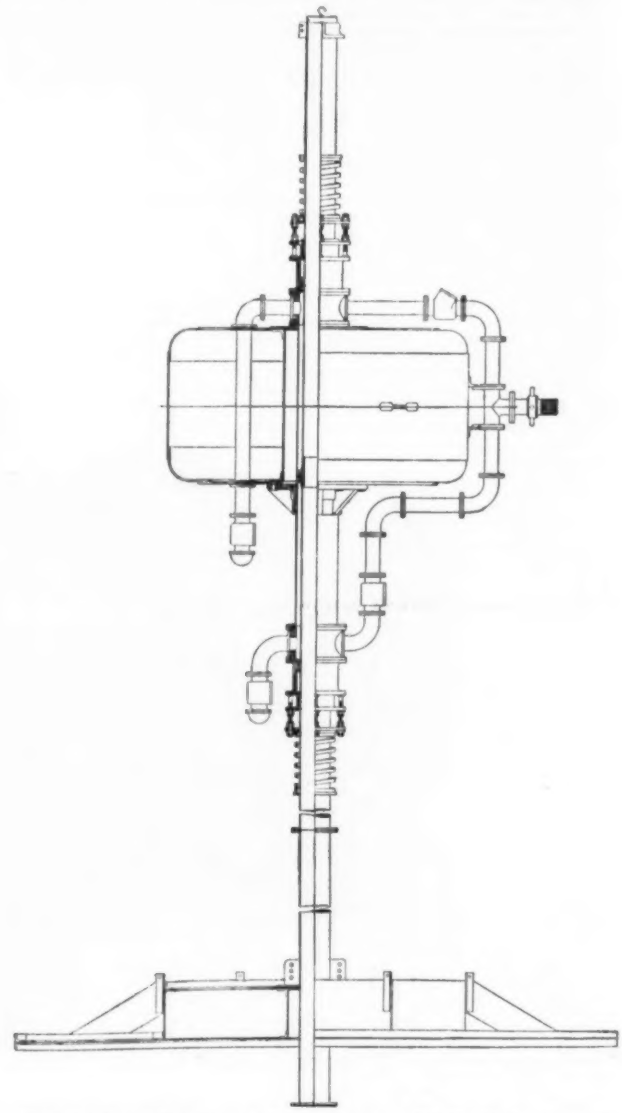


Fig. 2.—Part Sectional Elevation of 300 H. P. Apparatus.

THE UTILIZATION OF WAVE POWER.

Mr. B. Morley Fletcher, A.M. Inst. C.E., of Westminster, has for some time past devoted his energies and skill to the long-sought-for solution of this problem, and his invention, which we illustrate herewith, would appear to utilize available ample power at a practically nominal cost, and without in any way consuming material other than that arising from the abrasion of the working parts of his most ingenious apparatus. It may be said briefly that the essence of Mr. Morley Fletcher's invention is the provision of a point of resistance which is fixed in relation to the up and down motion of the waves. This is attained by means of a submerged horizontal plane or disk, which is anchored to the sea bottom by powerful and efficient moorings, chains, bridles, etc., due provision being made for the rise and fall of tides. This plate is placed at such a depth below the surface of the water that it is entirely unaffected by the action of the waves. The motor itself consists of two parts; first, a cylindrical tube or hydrometer at right angles to and firmly secured to the upper surface of the plate alluded to, and rising a few feet above the surface of the water. And, second, a cylindrical or other shaped buoy, which floats on the waves around the tube, and which has attached to it a pump-barrel, which in its turn works round the tube immediately below the buoy. The motion of the barrel is, therefore, synchronous with the movement of the waves, both in a vertical, horizontal, or angular

position. In other words, the pump barrel moves up and down in the direction of the waves, and the fixed tube provides a piston rod, i. e., instead of the piston rod moving in the barrel, the barrel moves up and down the piston rod. The water pumped can, of course, be conducted by suitable means to the shore, and there used and stored for hydraulic purposes, or it can be conducted on board lightships, piers, harbors, etc., and used for generating mechanical force in connection, for instance, with the generation of electricity for lighting, signaling, and other purposes; in fact, we understand that some negotiations have been made with regard to utilizing the apparatus for this purpose. The conditions of the sea and weather in no way interfere with the effective working of the apparatus.

Through the courtesy of Mr. Morley Fletcher we are enabled to illustrate in Fig. 1 the experimental apparatus by means of which the practicability and application of his invention was recently demonstrated in Dover Harbor, this small plant having been prepared and laid down solely for testing purposes.

We are informed that the results of the exhaustive and continued experiments then made, which were of a highly satisfactory character, fully warrant the further expenditure necessary for the construction and laying down of a much larger and more powerful plant. The Dover plant (Fig. 1), when in full work, is capable of developing about 3·7 i. h. p., with a maximum stroke of 4 ft., the diameter of the floating buoy being 4 ft. and the size of the pump barrel only being limited by the size of the buoy.

In Fig. 2 we are enabled to present a sectional elevation of the much larger plant now being constructed by Messrs. Maudslay, Sons & Field, the well-known marine engineers of Westminster. This apparatus, which has an inner tube 12 in. in diameter, is designed to develop 300 i. h. p. when working at full stroke, and when working at one-half stroke the arrangements are such that the same pressure of 150 pounds per square inch is obtained. Not the least ingenious portion of the designing of the apparatus is the controlling gear, which is provided to act when the sea is very rough; in addition, the buoy is so designed and placed as to be always from one-half to two-thirds immersed, so that the waves incidental to a rough sea will pass completely over it without in any way interfering with the efficient action of the pump, or causing injury to other portions of the plant.

In the event of the sea being what may be termed calm, or only subjected to a ground swell, it is proposed to duplicate or triplicate the plant, which, owing to its low cost, may readily be done.

We do not at present propose to further describe the details of this invention, since a practical demonstration of the working of the plant now under construction will take place as soon as convenient after its completion, to which we shall advert in a future issue. In the meantime, apart altogether from its importance as a mechanical factor on land, the invention appears to us most valuable in regard to the safety to be derived from it with respect to navigation round sea coasts, in channels, the entrances to dangerous estuaries and the like during foggy weather; for by fitting to the plant different apparatus for actuating and sounding foghorns or sirens, the restless action of the sea would at once enable the navigator to ascertain his true position; a system of varied colored electric lights, flash lights, etc., might also be devised and fitted on the buoy in a similar manner, and worked continuously or at will, both by night and by day, regardless of the condition of the weather prevailing at the time, thus rendering collisions, strandings and the like less frequent, and reducing the appalling loss of life and property in consequence thereof to a minimum. We are indebted to Industries and Iron for the particulars and the illustrations.

IMPROVEMENTS IN OPERA AND FIELD GLASSES.

FOR some years past, theater goers have seen a gradual increase in the installation of small automatic distributers designed to put a pair of opera glasses at any one's disposal for an entire performance through the introduction of a coin into a slot with which the apparatus is provided. The idea was a happy one and could not fail to prove a success. This is because the best opera glasses, despite their perfection as optical instruments, have never ceased to be very inconvenient objects to carry. All, in fact, present the grave inconvenience of being heavy and cumbersome in their cases, which it is impossible to put into the pocket and which must of necessity be carried in the hand or slung over the shoulder.

This defect of the ordinary opera glasses is so manifest that various specialists have for a long time been taxing their ingenuity (without much success, however) to find some practical arrangement of remedying it.

The problem, nevertheless, is capable of solution. In the traditional opera glasses the irremediable defect is their very form, and so it was absolutely necessary to discard this and have recourse to another and more practical one.

Starting from this idea, Commandant Napoleon Ney, who, in his capacity as an explorer, has more than once while on the road experienced the inconveniences of the common field glass, conceived the idea of trying to find some new arrangement that should permit of uniting in a small bulk, analogous to that of an ordinary pocketbook, the optical combination of a strong pair of glasses suitable for the theater, the race track and the field.

With the co-operation of Mr. C. Huet, a manufacturer of optical instruments, the project was soon realized in a practical and simple manner in the creation of the pocket opera glass. This, when it is closed, recalls, by its form and size, a cigar or card case. It is 4½ inches in length, 3¼ in width and ⅜ of an inch in thickness, and weighs seven ounces.

It is elegant in appearance and strongly constructed, and the various parts of its mechanism are of steel or aluminum.

In order to make use of it, it suffices to press upon a clasp, when the case will immediately open and set at liberty its optical apparatus, which the objective holder afterward renders immovable through a special catch.

The mechanical combination of the apparatus is very simple. At one side of it there is a small movable button, J, that serves to effect the focusing. This button actuates a rod which, in revolving, carries along a piece of steel, F, that acts upon the bar which supports the two eyepieces, AA. It will be seen that, thanks to this arrangement, it is impossible for the glass to get out of center.

The closing is effected by pressing upon a metallic button arranged in the center of the movable piece that supports the objectives, GG. In descending, this piece meets the rods, DD, that regulate the motion of the lateral shutters, then the tongue, B, that brings the oculars into the interior, and, finally, the spring, C, which keeps the objective carrier in its turned down position. This done, before putting the instrument

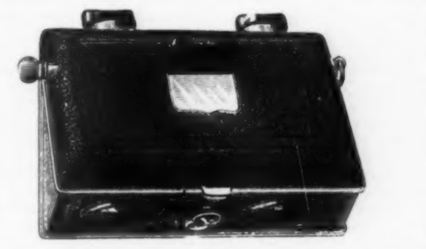


FIG. 1.—THE POCKET OPERA GLASSES OPEN.

into the pocket, one presses upon the cover, which thereby becomes fastened by a catch. But in this closed position the cover presses upon the spring, C, the effect of which is to free the objective carrier, so that the latter, which is then held in place by the cover only, rises as soon as the glass is opened by a pressure upon the catch.

This instrument, as may be judged by the above brief description, is really a convenient and practical one, and, what is of importance, is very luminous, it having a field of about five degrees and a magnifying power of four diameters. Despite its many good qualities, however, this pocket instrument would be unable to answer all requirements, such especially as those of the field, where soldiers on a campaign have continually to make observations at great distances.

For such purposes, Mr. Huet has succeeded in combining a double stereoscopic stadia-telemeter, which possesses advantages of the highest order.

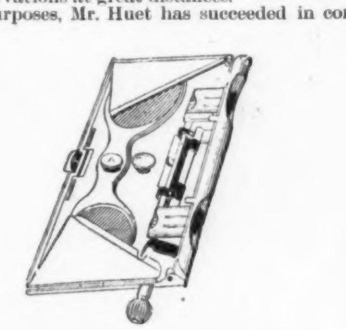


FIG. 2.—INTERIOR OF THE OPERA GLASSES CLOSED.

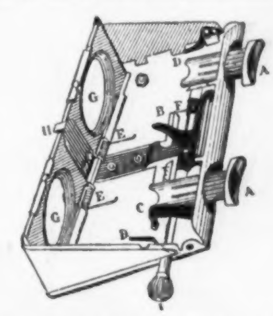


FIG. 3.—INTERIOR OF THE OPERA GLASSES OPEN.

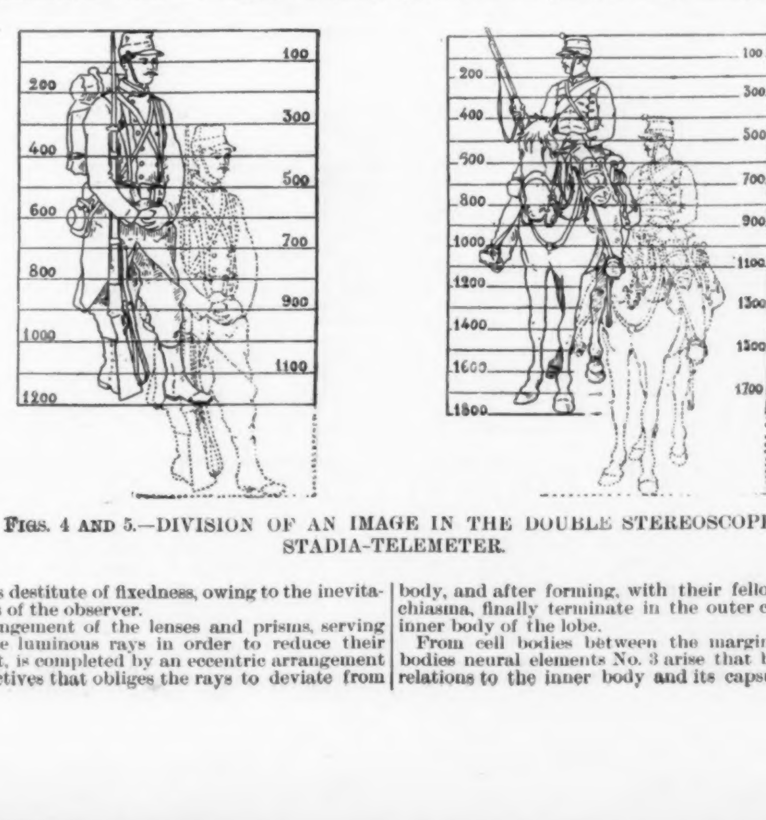
This new instrument, which is of about the bulk of a medium sized double opera glass, presents the peculiarity, which is very important in practice, of permitting of a proper estimate of the distance of the objects examined, of giving a very sharp definition, of having a visual field of six degrees, and of magnifying eight diameters. Moreover, thanks to a very ingenious combination of lenses of four total reflection prisms, it has been possible to reduce the length of the instrument to a considerable degree, so that when open to its full extent it measures but four inches. This is an extremely advantageous arrangement for field work, and especially for observations on horseback, which are very difficult to make with the ordinary field glasses of long focal distance, in which the images are always more or less destitute of fixedness, owing to the inevitable motions of the observer.

This arrangement of the lenses and prisms, serving to break the luminous rays in order to reduce their total height, is completed by an eccentric arrangement of the objectives that obliges the rays to deviate from the optical axis, and thus assumes a stereoscopic effect upon all objects, which are seen detaching themselves with a higher relief than in an ordinary field glass or with the naked eye.

In order to measure distances with the instrument, a dividing prism is brought before one of the objectives by means of a small wheel arranged for the purpose. If the observer then closes the eye which is not on the same side as the prism, he will distinguish simultaneously two images of which it is only necessary to estimate the spacing, which he will afterward compare with the figures engraved upon the slides of the instrument in order to obtain the actual distance without any calculation.

The double stereoscopic stadia-telemeter presents still another advantage, and that is that the spacing of the objectives is variable, thus permitting of bringing each of them exactly before the eye of the observer, so that all the sharpness of definition that the instrument is capable of giving may be taken advantage of.

As may be seen, nothing has been neglected in the arrangement of this apparatus, which is the most perfect of its kind that has hitherto been devised.—La Vie Scientifique.



FIGS. 4 AND 5.—DIVISION OF AN IMAGE IN THE DOUBLE STEREOSCOPIC STADIA-TELEMETER.

THE OPTIC LOBES OF THE BEE'S BRAIN.

By F. C. KENYON.

IN the optic lobes of the bee's brain there are, as in other hexapods, three masses of fibrillar substance surrounded more or less completely by masses of cells. The middle and inner masses or bodies may in section be recognized as composed of a pair of lenticular, densely and finely fibrillar bodies or capsules, fitted one within the other and with their convex surfaces directed outward, their concave surfaces inward. The capsules in each body are separated from one another by a loose mass of fibers running parallel to the surfaces of the capsules.

In the middle body this middle layer of fibers is gathered into a bundle at the anterior margin of the body and passes out toward the central portion of the brain. Almost immediately the bundle divides. One division goes to the calices of the mushroom bodies, forming thus the antero-superior optic tract; the other to the lower posterior portion of the brain, forming the antero-posterior optic tract.

From the middle loose layer of fibers of the inner body several bundles arise, all penetrating the hinder portion of the brain. One bundle forms an upper, another a lower commissure between the two optic lobes.

The fibrillar elements from the retina terminate in five branches, and thus help to form the outer mass of fibrillar substance. From cell bodies between the basement membrane of the retina and this mass fibers pass inward, give off short, fine fibrils connecting with the terminating fibrils just noted, and then go further inward, forming, with their fellows, the outer chiasma and terminate in a bunch of fibrils in the outer capsule of the middle body. These form neural elements 1. From cell bodies between the outer chiasma and the middle body fibers penetrate the outer capsule of the latter, giving off a bunch of lateral fibrils connecting with the terminals of elements No. 1. The main fiber then crosses the body to the inner capsule, gives off in it a group of short fibrils, then leaves the body, and after forming, with their fellows, the inner chiasma, finally terminate in the outer capsule of the inner body of the lobe.

From cell bodies between the margins of the two bodies neural elements No. 3 arise that bear the same relations to the inner body and its capsules as do ele-

ments No. 2 to the middle body. Passing out of the concave surface of the inner body, some of the elements are gathered into a bundle that passes forward, forming the anterior optic tract, and terminate in the optic body, a small oval mass of fibrillar substance above the antennal lobe. Others go upward as a bundle of fibers to the calices of the mushroom bodies, forming thus the postero-superior optic tract.

The branching terminals of the fibers forming the antero-superior optic tract seem to connect with the lateral fibrils of element No. 2 in the inner capsule of the middle body, and the terminals of the fibers forming the posterior optic tracts connect similarly with the inner lateral fibrils of elements No. 3.

A stimulus to a retinal element may reach the central portion of the brain by passing over three or four neural elements and may reach either the mushroom bodies, the optic body or several portions of the posterior part of the brain, or, passing over more elements, it may reach all these regions, and even be transferred over the two optic commissures to the opposite lobe, and thus indirectly reach the mushroom bodies, the optic body or the posterior portion of the brain on the other side.—Science.

THE BEAVER.

THE beaver is one of the most interesting animals known to natural history. It is a fur-bearing amphibious mammal of the rodent or gnawing order

THE BEAVER.

(rodentia). The two known species of beavers which are among the largest members of the group are found both in Europe and America, and measure from 2 ft. 10 in. to 3 ft. 8 in. from the tip of the nose to the tip of the tail. They weigh from thirty to sixty pounds, and are covered with a reddish fur, to which they owe their chief commercial value; their fur is occasionally yellow, and in rarer species is black, and cases of the albino or white beaver are known.

Beavers have powerful jaws, and eyes disproportionately small; their range of vision being short. Their ears are small, but their sense of hearing is very acute. Their sense of smell is very powerful. Their paws are small in proportion to the animal and compared with their hind feet. In swimming they are not used and fold under the body. Their hind legs are the propelling power in swimming, and the feet are fully webbed to the roots of the claws. Beavers are essentially aquatic in their habits, rarely traveling much upon the land unless driven to it by necessity. They differ from all other rodents in possessing a broad, horizontally flattened tail, somewhat oval in form and covered with scales. They use their tail as a wedge in their progress through the water, and not as a trowel for plastering their mud houses, as was formerly supposed. This common error is refuted by the fact that the animal always uses mud and soft earth as mortar, but it serves as a pounder to pack the mud and earth in constructing lodges and dams. Besides assisting in swimming and building operations, they can also strike a violent blow, the report of which can be heard at a distance of half a mile, it is said.

When the beaver stands erect, the tail is used as a prop.

The front incisor teeth in each jaw have a sharp chisel-like edge, and are so formed as to preserve this edge through life. As the creature gnaws, the soft material is worn away more rapidly than the enamel, which thus protrudes in a sharp ridge. The enamel is so exceedingly hard that these teeth fixed in wooden handles were used by the North American Indians in carving their weapons of bone.

The beaver was formerly much more sought after than at present. At the beginning of this century two hundred thousand skins were exported to Europe annually. The animal was then in imminent danger of extirpation, but as the demand for beaver skins became lessened by the substitution of the fur of the South American coypu, they have again become abundant in such of their old haunts as have not yet been occupied by man, so that the trade in the beaver skins has now almost attained its former proportion.

The flesh of the American beaver is considered quite a delicacy, the taste somewhat resembling pork. The American beaver is an essentially social animal, inhabiting lakes, ponds and rivers, as well as the narrow creeks which connect the lakes together. They generally prefer flowing water, probably on account of the advantages offered for transporting materials for their dwellings. They sometimes choose deep water, no doubt because it yields a better protection against frost. When they build in small creeks or rivers, the waters of which are liable to decrease and to be drawn off, instinct leads them to the formation of dams, which are shaped according to the nature of the particular location.

The common species of the beaver live in villages or colonies. Sometimes two or more families inhabit the same ground, but all of the inhabitants assist in constructing or repairing the common dam, but each family has its own lodge and lays in its own supply of provisions for the winter. The beavers carry on their work at night, so that very little is known of their way of conducting their building operations. To construct a dam they select trees invariably up stream of the place selected for their weir, so that the current will carry them down to the place where they wish to use them. They usually select trees five or six inches in diameter and cut them down with their teeth. If the current of the creek or river is gentle, the dam is carried horizontally across, but where the water runs swiftly it is built at an angle. The trees and the other materials rest on the bottom, where they are mixed with mud and stones by the beavers, and the deposits of the soil carried down by the stream help to render the weir secure. It is a mistake to suppose that the beavers drive in piles and plaster with mud, as has been so often described. The beaver conveys his building materials between his forepaws and chin, and arranges them with his fore feet, and when a portion is placed as he wishes it, he turns about and gives it a slap with his tail.

The beavers begin to build ordinarily in the latter part of August, although they sometimes fell their timber early in the summer. The houses are formed of the same materials as the dams. There is little form or regularity of structure. They seldom contain more than four old or six or eight young beavers.

It not unfrequently happens that some of the larger houses have one or more partitions, but these are really only posts in the main building, which are left by the sagacity of the builders to support the roof. It happens often that they have no communications with each other except by water. The beavers work with great expedition, and it only takes a short time for them to build their houses. Late in the autumn they cover their houses with fresh mud, which freezes when the frost sets in, so that the house becomes almost as hard as stone, and neither wolves nor wolverines, which are their worst enemies (after man), can obtain an entrance. The food of the beaver consists of the aspen, birch, poplar and alder and a plant called Nuphar luteum. It bears a resemblance to a cabbage stalk, and grows at the bottom of the lakes and rivers. During the summer they add berries to their menu. When the ice breaks in the spring, they always leave their habitations and roam about until a little before the fall of the leaves of the trees, and then they return to their old habitations and lay in their winter stock of wood. They seldom begin to repair their houses until the frost sets in. The beaver is easily domesticated and becomes very tame.

The trapping season begins in November and ends in March, but the hunt is pursued through the year. A trapper can manage from fifty to seventy traps in a circuit of thirty or forty miles. The number of beavers captured is not large. An Indian family comprising four good trappers will take from seventy-five to one hundred and fifty beavers in a season. For our engraving we are indebted to Der Zoologische Garten.

NOCTURNAL AND DIURNAL CHANGES IN THE COLOR OF CERTAIN FISHES, WITH NOTES ON THEIR SLEEPING HABITS.

By A. E. VERRILL, in Science.

WHILE investigating the nocturnal habits of fishes, etc., in the aquaria of the laboratory of the United States Fish Commission, at Wood's Holl, in 1885 to 1887, I unexpectedly discovered that many species of fishes, and also the common squid (Loligo Pealei), take on special colors at night, while asleep, or at rest, in a feeble light. These observations have not hitherto been published, because I hoped to have had opportunities to continue them and make them more complete. It is now my hope that others, with better opportunities, may take up the subject. My observations were made after midnight, when everything was quiet, for fishes sleep very lightly. The gas jets near the aquaria were turned down as low as consistent with distinct vision, and great care was taken not to jar the floor or furniture. With these precautions I was able to detect many species in the act of sleeping. Some of them took unexpected positions when asleep.

The most common change in colors of the sleeping fishes consisted in a general darkening of the dark spots, stripes or other markings, by which they become more distinct and definite. This was the case with various flounders, minnows (Fundulus), the black sea

bass (Serranus furvus), the sea robins (Prionotus evolans and P. palmipes), the king fish (Menticirrus nebulosus) and several other species.

In all these cases the change of color is in the direction of increased protective coloration, the dark markings being generally connected with their habits of resting naturally at night among eel grass and sea weeds. The young fishes often showed greater changes than the adults.

Other species showed a much greater change in color, for the pattern of coloration was itself entirely changed. Thus the common scup or porgy (Stenotomus chrysops), while active in the daytime, is of a beautiful silvery color with bright, pearly, iridescent hues. But when asleep it takes a dull bronzy tint and is crossed by about six conspicuous transverse black bands, a coloration well adapted for concealment among eel grass, etc. If awakened by suddenly turning up the gas, it almost instantly takes on its silvery color seen in the daytime. This experiment was tried many times.

A common file fish (Monacanthus), which is mottled with dark olive green and brown in the daytime, when asleep becomes pallid gray or almost white, while the fins and tail become black. These are nocturnally protective colors. The file fishes, when asleep, often lean up obliquely against the glass of the aquaria, with the belly resting upon the bottom in very queer positions. The tautog, or black fish (Tautoga onitis), commonly sleeps on one side, often partly buried in sand or gravel, or under the edges of stones, much after the fashion of flounders, thus suggesting the mode in which the flounders may have developed from symmetrical fishes in consequence of this mode of resting, becoming chronic as it were.

THE NESOPITHECUS, OR FOSSIL MONKEY OF MADAGASCAR.

THE great island, or rather the small continent, of Madagascar is as yet but slightly known to naturalists, and has doubtless many surprises in store for them. Its fauna and flora are so peculiar that their strange character attracted the attention of travelers as long ago as the last century. The botanist Commerson, who visited the island along about 1770, expressed this idea in saying that "nature seems to have retired to Madagascar, as if to a sanctuary, in order to work there upon models other than those to which she had been elsewhere tied down." Now, we should more simply say that Madagascar, like all the isolated lands of the southern hemisphere (Australia, New Zealand, etc.), possesses a fauna and flora of distincter character than those of the great southern continents.

The fauna of Madagascar is especially interesting by the contrast that it presents with Africa, of which geographers erroneously consider it as a dependency. This large island is a continent as distinct as Australia itself.

Madagascar, as well known, is entirely destitute of monkeys, while these animals abound upon the neighboring coast of Africa. They are replaced in Madagascar by Lemuridæ, animals, as shown by Mr. Milne-Edwards, that are of a different organization. But it is possible that things have not always been thus, and a proof of this seems to be found in the discovery of the curious fossil that we figure herewith, and that appears, from its characters, to be more closely allied to the monkeys than to the Lemuridæ.

We have already spoken of the discovery in Madagascar of a fossil maki of gigantic stature which Mr. Forsyth Major named the megaladapis. Shortly afterward the Museum of Natural History, of Paris, received some fossil remains derived from the same deposits, and which, likewise, belonged to large Lemuridæ that Mr. Filhol described under the names of dinolemur and thaumastolemur.

After these successive discoveries, Mr. Major resolved to go personally to explore the geological strata whence these debris came, and shortly afterward set out for Africa. His researches, which were interrupted by military operations, were resumed immediately afterward and were crowned with unhoped-for success—the discovery of an absolutely new type and one probably of great interest from the view point of the evolution of mammals.

The two principal parts upon which this type is founded were collected in the swamps of Sivabé, district of Vakinankavata, in the central region of Madagascar, a little to the south of Tananarivo. The species has just been described by Mr. Major under the name of Nesopithecus Roberti, the specific name having been given in honor of Mr. A. Robert, his assistant, who discovered the fossil remains.

The strata in which the remains were found are of very recent origin and are contemporaneous with those in which the remains of the epyornis are found.

One of the two pieces is an entire upper jaw with the nasal bones and a portion of the facial region comprising the orbital cavity and the zygmotic apophyses. The other is a lower jaw, but provided with an almost complete dental series. It is very probable that these pieces belong, if not to the same individual, at least to one of the same species, since they fit each other perfectly.

Although Mr. Major has no hesitation in considering these debris as having belonged to a mammal of the monkey family, we think there is reason for making some reservations in this regard. In fact, in all the living and fossil monkeys now known, including the American monkeys and even the oustitis, that are nevertheless so degraded, the teeth are equal in number in both jaws. Now, in the nesopithecus there exists in the upper jaw one pair of teeth more than in the lower. This is a difference of prime importance, and one that leads us to suppose that the nesopithecus should, in systematic catalogues, form not only a family apart, as Mr. Major admits, but also an order, or, at least, a particular suborder.

What remains of the skeleton of the face indicates that the facial angle was nearly the same as that of the Cercopitheci or guenons. The head was round, with a but slightly prominent muzzle. The orbits are directed toward the front and are separated from the temporal fossa by a bony dissepiment. The lacrymal canal is in the interior of the orbit. The nasal bones, seen in profile, are concave, and the internal incisors touch each other upon the median line. All these characters ally the nesopithecus with the true monkeys. On the contrary, the nasal bones and the interorbital region are wider than those of the monkeys. According to Mr. Major, this character is the only point of resemblance that the new type presents with certain lemurs.

The dental formula in the upper jaw is that of the Cebidæ or American monkeys, that is to say, two incisors, one canine, three premolars and three true molars on each side. The back molars have four tubercles and are almost square, like those of the Cercopitheci, save that they decrease from the first to the last, which is something that is observed likewise in several monkeys of the new world. The premolars are large, of nearly triangular section, are inserted obliquely and are imbricated by their external edge, whence it results that the last is almost transverse. The canine is quite strong, prominent and provided with an internal spur. The internal incisors are stronger than the external and inserted more to the front than the latter. There exists an interval between the second pair of incisors and the canine.

The lower jaw shows merely the alveolæ of the incisors, but it is seen that these teeth, to the number of four, as in the upper jaw, were proclivous. Of the six teeth that remain in place, the three posterior are back molars exactly like those above, and decrease likewise from the first to the last. The three anterior teeth must be considered as premolars, although the first is a little stronger and caniniform. But upon fitting the two pieces to each other, it is seen that this tooth places itself behind the upper canine, so that it must be considered as a premolar, according to the rules now established for the nomenclature of teeth. There exists no interval between this premolar and the external incisor, and the canine was therefore entirely wanting in the lower jaw. Upon the whole, this dentition, despite the relations that it exhibits with the Cercopithecidæ (by the form of the back molars), on the one hand, and with the American monkeys (by the number of teeth in the upper jaw) on the other, is, in reality, very peculiar, especially in the lower jaw.

Among the fossil monkeys that may be compared to this one, we find scarcely any except the Homunculus Patagonicus, described by Mr. F. Ameghino from remains derived from the tertiary of Southern Patagonia. The homunculus was a monkey of the stature of the ouistitis, and its upper jaw is unfortunately not known. But its lower jaw, which we figure alongside of that of the nesopithecus, presents, like the latter, immediately after the incisors, a "premolariform" tooth, to use Mr. Ameghino's expression, and which may be as well regarded as a premolar as a canine. The third back molar is wanting in the jaw that serves as a type for this genus. We may suppose that the lower dental formula was identical with that of the nesopithecus.

The relations that the nesopithecus presents with the Lemuridæ are more doubtful. Yet these latter want the canine in the lower jaw, or rather such canine is replaced by a tooth that is exactly like the incisors. In the adult indri the lower canine is wanting, without its being represented by an incisor. In the young of this same species we find three premolars and three back molars behind the caducous canine. It suffices to suppose that this canine dropped out with age and the anterior premolar was preserved in order to have exactly the dental formula of the nesopithecus. The genus Hapalemur approaches the latter in the characteristic arrangement of the two pairs of upper incisors.

But such resemblances are doubtless simply adaptative; that is to say, due to the influence of an exclusively vegetable diet. And we are disposed to believe with Mr. Major that no real affinity exists between the Lemuridæ and the nesopithecus.

Perhaps we should reach a more positive result if we compared this latter with another group of extinct mammals whose natural relations have also remained for a long time problematical. We refer to those ungulate fossils that are now referred to the swine family and that were at first described as monkeys under the names of Cebochœrus, Macacus eocœnus, Colobus grandœvus, etc. The back molars of these tertiary ungulates resemble those of the monkeys, and, consequently, those of the nesopithecus. In the group of Suidæ, also, the teeth sometimes differ in number in the two jaws (in the Chœropotamus, for example).

If, then, we admit with Mr. Milne-Edwards that the Lemuridæ have descended from some type allied to the herbivoræ, we may also admit that the monkeys, and especially the nesopithecus, are modified forms derived from omnivorous mammals more or less allied to the tertiary Suidæ from which have been erected the genera Hypotherium, Acotherulum, Chœropotamus, etc.

Such a hypothesis is perfectly compatible with that of Mr. Major, who, in the nesopithecus, sees a synthetic type closely related to the common ancestors of the Cebidæ and Cercopithecidæ.

In a preceding article, in speaking of the megaladapis, we reproduced a curious description, given in 1658 by Flacourt, of the trétrétrétré, a quadrumana with human face that was still living in his time in Madagascar, and we supposed that it was a question of an animal more or less closely allied to the megaladapis, while at the same time recognizing the fact that the latter, with its elongated muzzle, corresponded but incompletely to Flacourt's description. Now that we know the nesopithecus, it is evident that this description applies much more exactly to the latter, which, in fact, must have had a round head and a human face, like Flacourt's trétrétrétré.

This is one reason more for desiring that new researches may make better known to us this very interesting type, which, according to all appearances, became extinct only at a relatively recent epoch.

In the meanwhile we give a figure of the two pieces upon which the description of the nesopithecus was based. Along with them we figure the lower jaw of the dryopithecus, a large anthropoid monkey of the miocene of France, in order to give an idea of the size and characters of the new type from Madagascar. Finally, we give also a figure of the lower mandible of the Patagonian homunculus.—E. Trouessart, in La Nature.

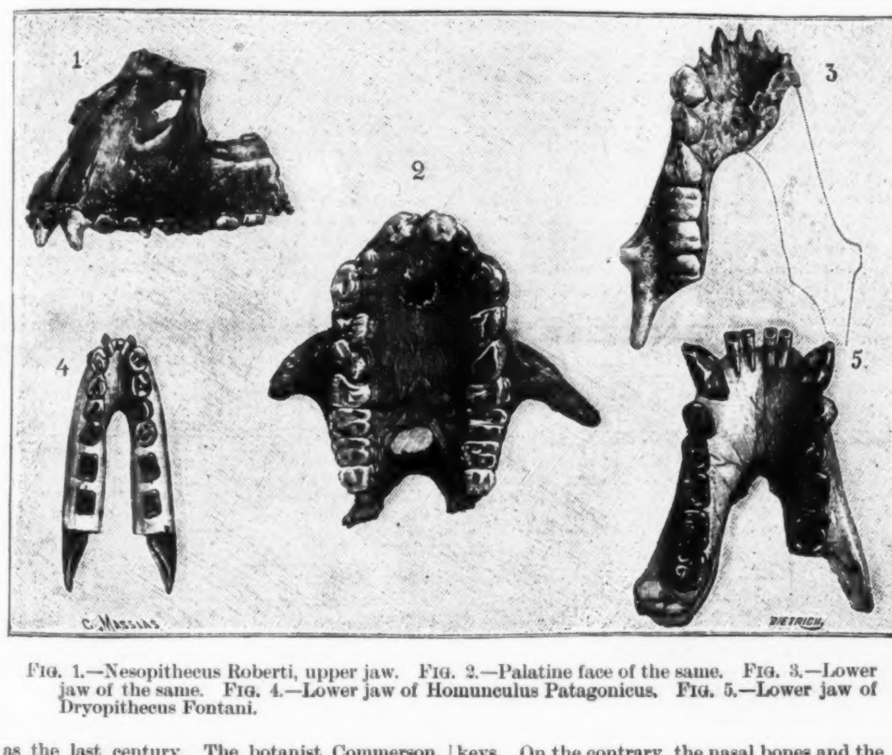


FIG. 1.—Nesopithecus Roberti, upper jaw. FIG. 2.—Palatine face of the same. FIG. 3.—Lower jaw of the same. FIG. 4.—Lower jaw of Homunculus Patagonicus. FIG. 5.—Lower jaw of Dryopithecus Fontani.

HOW TO OBSERVE AN EARTHQUAKE.

By CHARLES DAVISON, Sc.D., F.G.S., in Knowledge.

THE phenomena of earthquakes attain a very simple form in this country. To realize this we have only to compare the severest of recent British shocks with one of the great disturbances of other lands: say the Essex earthquake of 1884 with the Charleston earthquake of 1886 or the Japanese earthquake of 1891. In the former case, though many buildings were damaged and chimneys thrown down, the shock only lasted a few seconds; there were no great fissures in the ground, no crumpling of railway lines, no changes in the earth's surface features, such as the compression of river valleys, or changes of level along lines of fault. There was some, though comparatively little, derangement of the underground water system. Two months after the earthquake a single slight shock was felt, that would hardly have attracted any notice had it not been for the interest already aroused in the subject. How different is this from the case in Japan! During the day following the disastrous earthquake of 1891 no less than three hundred and eighteen shocks occurred. The daily number, of course, rapidly declined; but before little more than two years had passed, as many as three thousand three hundred and sixty-five shocks were recorded at an observatory situated a few miles from the chief center of disturbance.

The simple character, the short duration, and the isolation of British shocks are distinct aids to their observation; the attention is not distracted by a multiplicity of details. As the shocks are almost invariably slight, panic and the consequent exaggeration of description are to a great extent avoided. Their rarity is even, in one sense, a point in their favor. This is especially the case, as I have often found, when a seismologist endeavors to collect information from observers in different places, for those who have felt only one or two shocks in their lifetime retain for long the vivid impression they produce.

On the other hand, previous inexperience of earthquakes militates against their accurate observation. The shock begins so suddenly, and is often of such brief duration, that, almost before its true nature is recognized, it may be over and all opportunity for

detailed study gone. In such cases, while some points stand out clearly enough and can be easily described, especially with the aid of guiding questions, others of perhaps equal importance escape notice, or the recollection of them is afterward too indistinct or confused to be reproduced without uncertainty or error.

It is not difficult, however, to attend to the principal phenomena—those which will be of the greatest service in determining the surface position of the center of disturbance and in throwing light on the nature and origin of the earthquake. To describe these phenomena and to point out others which are less deserving of notice may be of some assistance to those who live in the districts which are occasionally visited by earthquakes, and who are desirous, when one does occur, of making the best use of the brief time at their disposal.

It should be mentioned at the outset that the nature or order of the earthquake phenomena may vary much at different points of the disturbed area. At a place not far from the center of the area, a low, rumbling sound is first heard; this gradually becomes louder, and after one or more seconds a slight tremor is felt, both sound and movement increase together in intensity, and then gradually die away, the sound lasting a few seconds after the movement ceases to be sensible. At its commencement the tremor resembles that produced in a building by a passing carriage or train, but, as it gets stronger, separate vibrations are perceptible. There is, indeed, no real distinction, except in magnitude and duration, between the tremulous motion and the perceptible vibrations. The movement sometimes, but not always, ends with tremors like those at starting.

At places near the boundary of the disturbed area the phenomena are of a simpler nature. If the shock be a strong one, and the disturbed area consequently large, it is possible that no sound at all may be heard, and the only thing observed is a more or less feeble movement. But in most earthquakes in Great Britain the sound is heard as far as the shock is felt. In such cases, at a place some distance from the center, the sound may be heard first and may cease entirely before any motion is felt, or, at any rate, soon after it begins. The instant when the sound is loudest thus precedes the instant when the shock is strongest.

Very frequently, after a pause of a few seconds, the same phenomena are repeated with greater or less intensity, the movement and sound nearly or quite dying away in the interval.

In describing the nature of the shock it may be convenient to distinguish the tremulous motion from the principal vibrations, applying the latter term (principal vibration) to each distinct and complete to-and-fro movement. When the separate vibrations are so rapid and small as to be imperceptible from one another, the term "tremors" or "tremulous motion" should be used.

Very often a sense of direction is perceptible, and in many descriptions some importance seems to be attached to this. If, however, these directions as observed at different places are all plotted on a map (I am speaking here of British earthquakes), they are found to be governed by no definite law; they do not diverge from any particular point or area. One reason, no doubt, is that the direction itself at any place may change during a shock; but even if this were not the case, the apparent direction within a house is so largely governed by the direction in which the house itself vibrates—i. e., by that of its longer axis—that observations on direction are generally of little, if any, value. It does not seem advisable, therefore, to pay much attention to this point, and the time often given to it may, as a rule, be more profitably bestowed.

Another point on which valuable time is often wasted is the determination of the time of occurrence. The first impulse of an observer, when he begins to feel a shock, seems to be to pull out his watch. Now, if the watch were very carefully regulated, or if its deviation from correct Greenwich time could be ascertained soon afterward, it would be of the highest importance to determine the time of occurrence, especially if this could be done accurately to within a few seconds. But at the present day comparatively few watches can be depended on to this extent, and not many persons are able within a few hours to compare their watches with an accurately regulated clock. It is seldom, indeed, that observations of the time are of any use for determining the velocity with which the earth wave travels. It should be remembered, too, that an appearance of accuracy, where none really exists, is easily given, and is most misleading; it would be better far if such an observation had never been made. As a general rule, therefore, when an observer is unprovided with a really good watch, he will spend his time more usefully in giving his whole attention to the nature of the shock and the accompanying sound. When the earthquake is over he should then record the time, and it is not difficult to estimate the brief interval which has elapsed. When, as is often the case in this country, successive earthquakes are separated by months or years, an error of a minute or two is not of much consequence. The time, however, should always be recorded as nearly as possible, if only for the purpose of identifying the shock with that observed by others. Sometimes also it is useful in tracing a doubtful or reported earthquake to its real origin, such as the firing of heavy guns at a distance, or the bursting of a meteor.

The preceding remarks apply in part to the duration of the shock. There is no difficulty, of course, in determining this with some accuracy; but here again the time can be more usefully employed. The duration is an element of little importance, unless it is determined by a seismograph, because the instants at which the movement begins and ceases to be perceptible depend entirely on the sensitiveness of the observer; and this varies in different persons, and even in the same person at different times. For all practical purposes, the direction can be estimated with sufficient accuracy when the earthquake is over. The observer should place himself in the same position as that in which he felt the shock and then imagine it repeated, marking the begining and end, the aid of another person being obtained to time the interval.

One of the most important points to which an observer can direct his attention is the intensity of the shock. If nothing else but the mere occurrence of the sound and shock were noted, this element should not be omitted. Fortunately we are provided with a rough scale of seismic intensity, which has met with general adoption in nearly all countries where earthquakes are studied, and which is accurate enough for most purposes, besides being most easy to apply. This is known as the "Rossi-Forel" scale of seismic intensity.* It should be noted whether doors, windows, etc., all rattled, or only one or the other; and whether the rattling was violent or slight. On the subject of intensity, however, the observer should not rest satisfied with his own impressions. He should make inquiries of his neighbors and others situated at a short distance in the same town or village, for the intensity often differs considerably at two points which are not very far apart.†

The last subject which need be referred to here is the observation of the sound phenomena. These, as a rule, are somewhat neglected, and yet they may prove to be of considerable importance, especially in concert with a large number of similar observations made elsewhere. The earthquake sound should of course be carefully distinguished from that produced by the rattling of loose objects, or, in rare cases in this country, by the fall of masonry. There is, indeed, little risk of confusion, for the earthquake sound does not resemble very closely any ordinary noise. On this account it is somewhat difficult to describe; but it is often compared to thunder (especially the low roll of distant thunder), the passage of a traction engine or heavy vehicle along a rough road, the dragging of furniture across the floor of a room overhead, the roaring of a chimney on fire, or the rush of a gust of wind. Sometimes it is more or less short and abrupt, like the firing of distant cannon, the fall of a heavy body, or the slamming of a door; and occasionally it resembles a succession of these, such as would be produced by a hard and heavy ball rolling down a short flight of stairs. Particular attention should be paid to the time relations of the shock and sound—whether the beginning of the sound precedes, coincides with, or follows the beginning of the shock, and similarly with regard to the end. A rough curve might with advantage be drawn, showing the variation in intensity of the sound, and, if possible, this curve should be combined in the same figure with the curve of intensity of the shock—a dotted curve, say, for the sound and a continuous curve for the shock. Such a figure would exhibit at a glance nearly every detail (except the absolute intensity and the time of occurrence) which it is desirable or necessary to observe.

The order in which the observations should be made and recorded is of great importance. The following is suggested as a convenient one, though the experience or inclination of each observer may lead him to adopt various modifications: 1. While the earthquake lasts the whole attention should be given to observing the nature of the shock and sound and their relations to one another; the variations in intensity and character of each. 2. Immediately the earthquake is over, take the time (in the following order: fraction of a minute or second, minute, hour), and estimate the interval between the instant when the shock was strongest and the instant of taking the time. 3. Write notes on the nature of the shock and sound, and their relations to one another. 4. Estimate the duration of the shock and sound, and the intervals between the beginning of each and the end of each. 5. Record the intensity. 6. Write notes about the position and occupation at the time of the earthquake.

THE SOCIAL CUSTOMS OF THE ZULUS.‡

IT is about six years since the daughter of Bishop Colenso began her appeal to the government and people of this country on behalf of the imprisoned Zulu chiefs at St. Helena. Those who listened to her first public address could not fail to be struck by the intense feeling with which Miss Colenso pleaded for the liberation of her friends, for as such she regards the Zulu prisoners. She was present throughout the whole of the trials in Zululand, extending over nearly five months, and came to the conclusion that they were little more than a farce. It was after sentence had been passed that she came to England to state facts as she knew them, returning to her South African home in 1893 to pursue investigations there. Two years ago, leaving her sister behind to hold the fort, she came back to London to still further work for the release of those whom she believed to have been unju tly imprisoned, and she is now not without hope that, Mr. Chamberlain being favorable, they will shortly be set free and allowed to return to their own country. A more disinterested work than that which Miss Colenso has undertaken it would be difficult to imagine, and one feels that there must be something essentially worthy in the character of a people who have secured so stanch a friend. Miss Colenso lived in South Africa continuously from 1855 until the death of her father in 1883, save for over three years' stay in England, and has also spent much time there since, so that she has had exceptional opportunities for judging the character and customs of the Zulus. At Bishopstowe, that quaint many-gabled house standing in the dreary stretch of country beyond Maritzburg, high up on a hill and surrounded by gum trees which the good bishop's hand had planted, Miss Colenso frequently played hostess to the great Zulu chiefs. Indeed, the door of Bishopstowe was ever open to the oppressed, and the house was not only an oasis to the eye in that great desert of yellow grass amid which it stood, but was regarded when the Zulu troubles began as the one white man's dwelling where racial distinctions were forgotten and common human rights conceded without regard to color. It is not, however, the purpose of this interview to discuss the political aspects of the Transvaal war, the capture of Cetshwayo, or the imprisonment of the chiefs which followed, but rather to give Miss Colenso's account of the social customs of the Zulus, for whom, as a race, she entertains a very high respect and appreciation in spite of the obvious fact that "their ways are not our ways;" in some respects Miss Colenso would be inclined to think that we should be better if they were, or at least that we should approximate more nearly to the fundamental laws of right and wrong if we meted out justice more from the human standpoint and less from the national. To judge of the "noble savage," however, we must bring him to the bar regarding the treatment and social condition of his women folk, which is held to be the test of the nobility of a nation.

"What is the position of the Zulu women," I asked Miss Colenso; "are they entirely downtrodden?"

"I do not consider that they are at all downtrodden. As an example of the honor which is paid to women, take the fact that women have ruled as great chiefs among the Zulus. There is no written or unwritten salic law."

"Still one can understand, Miss Colenso, that at certain epochs in the history of a tribe a woman of warlike spirit and regal attributes may arise and gain dominant influence, while the women generally are still kept in a very degraded condition?"

"Certainly; but to turn to the more purely social aspect of the question, take the position of the ordinary married woman. Polygamy is of course the custom of the country, but each wife demands and has a separate hut for herself and her children, and it is very much her castle; only the husband has a right to enter it and she need not allow another wife or the children of another wife to cross the doorstep against her wish. It is in a sense her property, not that she could sell it, but she has a dominant ownership. No Zulu would dream of marrying another wife until he was in a position to provide her with a separate hut. This system imparts a dignity to the wife which is not found among polygamous people where a separate home is not provided for each wife. You have none of the petty jealousies and quarreling which distinguish the harems of the East among Zulu women, who, as a rule, are most friendly to each other, and the many wives of a great chief will live in a little colony of huts, each mistress in her own house and family and interchanging friendly visits with the other ladies similarly situated. I am sorry to say, however," continued Miss Colenso, "that this is a custom which our civilization has a tendency to stop, and it is doing great harm among the Zulus. The British government now levies a separate tax upon each hut and this brings about overcrowding and induces natives who are not rich men to make one hut suffice for several wives and families."

"But the difficulty might be met by the Zulus contenting themselves with one wife as well as one hut?"

"That of course raises the difficulty as to how far we are at liberty to force our customs and civilization upon the native people. A great chief is held to have a duty to his tribe, and a part of that duty is to leave a large family behind him. For example, Lgngalibalele and Umpande, two of the most considerable of the chiefs, had more than a hundred wives and an immense number of children. It should be remembered that Zulu women do not have large families, because of the many wholesome customs which prevail among them. They think it disgraceful if a second child is born before the former one is well into its second year. Then there are no early and improvident marriages as with us. The native Zulu law forbids a man or woman to marry without the king's consent, and that cannot be obtained until the man has won his spurs. Permission to marry is granted to men and women at about the same age and they are told off in regiments. I have used the word 'regiment' as it applies equally to girls, but in this sense it has nothing to do with fighting."

"Still there are Amazons among the Zulus, are there not? We have had some very warlike specimens exhibiting themselves in this country."

"There are no Amazons among the Zulus proper, and any Zulu women who figured as such here were doing it simply for exhibition purposes, and had been trained to perform warlike feats, just as acrobats are trained in gymnastics. People are greatly misled who think that exhibitions of that kind represent native customs. When I use the word 'regiment' in application to girls and young men it has a civilian meaning. It will be better understood if I explain that the land was considered the property of the tribe and was held by the chief as a trustee. What is called the 'chief's work,' whether civil or military, is performed by levies of young men, called 'amabuto,' a word commonly translated soldiers, but properly meaning collections of people of the same age, whether of soldiers or workmen, of girls or of boys. The whole tribe is thus classified. This system has been called the Zulu military system. The great Zulu chief Tshaka added to it a regulation forbidding marriage to the younger regiments of boys and girls alike, until the former were, by general consent, allowed to have won their spurs. Under this system the young men are called out by the chiefs in 'regiments,' for planting, weeding, building or shifting the huts, forming their towns or villages, or for police purposes, as well as for war; a custom which might be followed to advantage in this country."

"What is the age at which young Zulus enter the service of the chief, either for war or civilian's work?"

"The Zulus keep no exact record of age except by events, but they have wonderful memories. If there has been a great storm, or a big battle, or a drought, all the children born the year before or after the event are classed together as being of the same age. When boys are considered old enough for service they gather at the police station, or rather used to, and signify their fitness for work by milking the state cattle into their own mouths, which means that they wish to belong to the king and feed on his food. The king then summons the recruits, and if he approves them he appoints an officer and forms a regiment; henceforth they are considered soldiers. They do not live in barracks, but go backward and forward to their respective homes. In times of peace they tend the land, and if war breaks out follow their chief to battle."

"Now," continued Miss Colenso, "much has been said about the aggressive attitude of Cetshwayo and his men toward the white settlers, but it is a remarkable thing that the year before we raided Zululand a set of boys were brought to the king for inspection, in the usual way, and he told them to return to their mothers, as he thought that they were too young for service—that did not look like making preparations for war. About the same time he also gave permission to two full grown regiments to marry, without having distinguished themselves in any way, on the ground that it was no use keeping them waiting any longer, as he did not see any fighting in prospect."

"When permission has been granted to a regiment to marry, does the king regulate the matches? Is there any system similar to that of the Moravians, where the

* For a full translation of the scale, see Nature, vol. xiii, 1890, p. 349.

† See a paper by Prof. J. Milne, "On a Seismic Survey made in Tokio in 1884 and 1885." Japan Seismol. Soc. Trans., vol. x, 1887, pp. 1—36.

‡ An interview with Miss Colenso, in the Humanitarian.

authorities practically decide which girl a man shall marry, and there is little freedom of choice?"

"There is certainly freedom of choice among the Zulus, the only restriction is that the young people must select one another out of the regiments 'told off' to marry, or out of older ones. Courtship among them goes on as it does all the world over, falling out and in again. It varies a little according to the position of the lady or her inclination. There is a sort of leap year arrangement which permits a girl to make the proposal of marriage. It is managed with the utmost decorum and secrecy. For example, if a Zulu girl has set her heart upon a young man, she will suddenly disappear from her home—her relations are not supposed to know where she has gone—and taking a confidential friend with her, she goes to the home of the favored swain, and if his parents receive her, she is treated as his future bride, and arrangements for the wedding begin. If she does not find favor with the young man, her visit is not received, she is returned to her own home with thanks, the object of her unrequited attachment usually making a handsome present to ease her feelings. A very romantic case of this kind came under my own notice. I had a dear little maid servant, she was quite a young lady in her way, and was the daughter of the first chief my father befriended when he was sent prisoner to the cape. She was taken care of at the mission and educated at our school, after which she came into my service. Her ways were very nice and particular, and she was most refined and delicate in her feelings. As the daughter of a great chief, she would have had many suitors if it had not been for European intervention, but as it was the poor girl was quite 'out of it.' In due time, however, my young friend suddenly disappeared. She had set off, I discovered, with a companion for the home of one of the principal chiefs. Her visit was received with favor and she is now his honorable wife and occasionally comes to see me when I am at home in Natal."

"Is there anything answering to our divorce laws among the Zulus, Miss Colenso?"

"There is such a thing as divorce. A husband may send his wife back home for misconduct. If this is proved, then the husband takes back the cattle which he gave as a marriage offering."

"Then does a Zulu husband purchase his wife?"

"The cattle which a bridegroom hands over to the bride's family are not the price paid for a wife, but merely a kind of hostage for her good conduct. If she misbehaves, she goes back to her father and the cattle are returned. The higher the rank of the lady, the larger the offering is expected to be. When a great chief marries his principal wife, who is to be the mother of the heir, the whole tribe make the offering to the bride's parents, as it is considered a national duty. There was originally no mercenary feeling in the matter, but we have introduced that by fixing the number of the cattle. The marriage law is very strict among the Zulus, and it is enforced equally on both sexes. Under the old law adultery meant death for the two offenders. An incident arising out of that was the alleged excuse for invading Zululand, although it only happened when our preparations for war were far advanced. Two wives of a Zulu chief left home with Natal lovers. Two sons by other wives followed and carried back the women and put them to death. This was, of course, an extreme measure, which I do not defend. The British government demanded that the king should find the two sons and hand them over to be dealt with by the Natal government. He replied, as I believe truthfully, that the men were in hiding and could not be found, and offered to pay a fine, as he was unable to comply with the demands of the government. The authorities would not accept this, and this incident was alleged as one excuse for the invasion of Zululand. The point of the incident is that it took place when our gunboats were ready on the coast."

"To return to the position of the Zulu women, Miss Colenso, how does native law affect the position of a mother to her children?"

"The relation of parents to their children is a very good one. Honor thy father and thy mother is the first commandment in Zululand, and the custom of each wife having a separate hut conduces to the respect in which children hold their mother. Her will is law in the home, and the charge of the family belongs specially to her. So much is the home the wife's castle that she can shut the door against the husband when she chooses. I have heard an angry woman say to her husband, 'Not a scrap of food shall you eat to-day,' and he slunk away quite meekly. The women do all the field work, except the large tracts, which are hoed by the Zulu soldiers in time of piece; consequently the crops belong to the wife, and this gives her additional power. Our civilization is breaking down this custom through the importation of ox plows, which brings men into the field because it is against native etiquette for women to have anything to do with cattle."

"But is not this an improvement, for under the old system the women must have been little better than beasts of burden?"

"They were certainly not that," replied Miss Colenso, with decision. "A Zulu woman with a hut of her own and her children around her, and a nice little patch of land which she cultivated and reaped the produce, assisted by her boys before they were old enough to serve the chief, was a person of some consequence. I am not sure but that many English wives might envy her life of freedom and independence, and, as to field labor, it is not regarded by a Zulu woman as more drudgery than the work about a house performed by a European woman of the same social position, and it must certainly be admitted she is allowed possession of the fruit of her labors, which English law has, only within modern times, given to our women, and even now the unwritten social law is prone to regard the husband as sole proprietor of the joint earnings of himself and wife."

"Are the Zulus precise in matters of etiquette and social behavior?"

"Particularly so. They have rules for everything, and it is impossible in short space to enter into detail regarding them. There is the proper etiquette for how a door should be opened, how you should enter a room and how you should leave it; in fact, the most ordinary acts of everyday life have all to be performed according to certain social rules. The Zulus are a particularly ceremonious people. They are also a very reverent and loyal people and friendly disposed toward any strangers to their country whom they feel have come upon a just and right errand. In 1843, when the English government took Natal by force from the Boers, the Zulus accepted the situation because they were satisfied, as they said, that just people had come near them and there would be no trouble, and therefore no claim was made upon the English people to restore land which was the property of the Zulus. Thirty-five years of absolute peace and security between Natal and Zululand followed. The troubles arose, of course, when the Boers attempted to seize a portion of Zululand and levy taxes upon the Zulus, who naturally expected to be defended by the white man whom they had so freely welcomed. They have no objection to the Queen's authority, but they still lament the partition of their country, and long to have their imprisoned chiefs back again."

"It might not be out of place here," continued Miss Colenso, "to say a little about the important part which cattle play in the life of the Zulu people. They have no money, of course, and their entire wealth consists of cattle; they have furs and weapons as property, but still the national treasury is filled by cattle captured in war. They do not belong to the king, but are held by him in trust for the people, like the land. He has the power to distribute the cattle among tribes and chiefs to be held as national property. Every Zulu in the country has an interest in the cattle, and the king has only power to use them for kingly purposes, that is, to feed the regiments and to make offerings for his principal wives. Any attempt on our part to seize the cattle was sure to exasperate the people—was mere mockery. In one of the blue books, the notorious Colenbrander has stated on oath that the customs of the Zulus and the Matabeles are identical. Now this is an interesting point to be remembered in connection with our recent troubles in Matabeleland. After the first war not only were all the 'king's cattle' taken by the Chartered Company, but a portion was given to certain chiefs to be their private property, making confusion more confounded, as it was tantamount in the eyes of the Matabele to taking national property and bestowing it upon favored chiefs. Many troubles in dealing with uncivilized races might be avoided if we only took the trouble to know something of their social and national customs and give them proper consideration. Many of the customs of the Zulus are to be found in ancient Jewish history. I have seen Zulus who, in appearance, might have been the originals of Assyrian figures on the bass-reliefs in the British Museum; and the photographed profile of a statue of one of the shepherd kings of Egypt reminded me promptly of a personal friend. The modern Zulus can trace back their chiefs for at least twelve generations, and they have an intense pride in the original race which came, they believe, from the north, to whom they refer as 'the grand old Zulu people.'"

"The mention of the great wealth of the Zulus being in cattle raises the point of the national appetite—do you consider, Miss Colenso, that the Zulus are a voracious people?"

"I do not consider that they are excessive meat eaters. When a man in a village kills a beast—well, you know it must be eaten; it will not keep, and all the neighbors come in to share. They have a feast, it is true, but it is a mistake to suppose that they gorge themselves. The chiefs I know best are the royal family and they have never shown very large appetites when I have entertained them to dinner. When they visited us in Natal, we provided them with a small joint, say a shoulder of mutton, with bread and potatoes, and there was always plenty left for their attendants after they had finished. Boys, until they are grown up, feed largely upon milk, which is always curdled. The great chiefs eat meat daily, and never have milk except at their mothers' homes. The native beer is drunk in fairly large quantities, still it is not merely an alcoholic beverage; it is made from millet and is quite thick at the bottom, and is stirred up before being drunk. I have indulged in it myself, and at one Zulu house where I visit they keep a special tin cup or pannikin reserved for my use; such a nice, courteous act. But it should be understood," said Miss Colenso, in conclusion, "that the Zulus are a very fine people and certainly not so low and degraded in their social customs and habits as is frequently supposed."

SARAH A. TOOLEY.

THE ADVANTAGES AND DISADVANTAGES OF THE USE OF STERILIZED MILK FOR INFANT FEEDING.*

THE term sterilized, as applied to milk, has been very vaguely used during the last few years. At first no doubt it was restricted in its application to milk which had been so treated as to be rendered germ free. Now, however, it is generally understood to refer to that which has been kept for some minutes at the temperature of boiling water. It is in this latter sense that I propose to use the expression to render milk approximately germ free. Carbonate of soda, bicarbonate of soda, boracic acid, borax, salicylic acid, quicklime, hydrogen peroxide, carbonic acid and formalin have been used. The necessarily small quantities which can be used of the substances have been proved, on the one hand, to be quite ineffectual for the destruction of germs, and on the other they are most injurious to the consumer when taken for a considerable period. The use of compressed oxygen and the passing of an electrical current through the milk have been suggested as sterilizing agents, but nothing practical has come out of these proposals.

Dr. Seibert, of New York, states as the result of a prolonged investigation that if milk be filtered through half an inch of compressed absorbent cotton, seven-eighths of the micro-organisms contained in it will be removed, and that a second filtration will further reduce the number to one-twentieth. One quart of milk may thus be filtered in fifteen minutes; however, Lewi found that the souring of milk was not at all retarded by this procedure. Of course efficient filtration, as through a Chamberland filter, is out of the question with milk. Cold is of value for preserving milk for a limited period, but is of no use for the purpose of rendering it germ free.

The various modes of rendering milk approximately sterile by means of heat are, therefore, the only ones which are of any practical importance. They may be subdivided into:

(a) Pasteurization, where the temperature of the milk is not raised above 158° F.; and

(b) Sterilization, where the temperature is raised to 212° F.

Various forms of apparatus have been invented for the pasteurization of milk in large quantities. These are chiefly of two types; in the one, such as Thiel recommends, the milk is made to flow over a heated corrugated surface, and in the other, the vessels containing the milk are surrounded by water, the temperature of which can be kept at a definite point for a definite period. The first kind of apparatus is almost useless, for, first, in order to render it certain that the whole of the milk is raised to a sufficiently high temperature to sterilize it, the metal must be so greatly heated that the milk which comes into direct contact with it will be scorched; and, secondly, the time of exposure to the temperature of 155° is far too short to be effectual. This has been proved by Geuns, who found that milk which had been treated in Thiel's apparatus still contained from 5,000 to 9,000 bacteria in every ten drops. If pasteurization is to be effectual, the milk must not only be heated up to a temperature of 155° F., but must be maintained at this temperature for twenty minutes. Bitter has invented an apparatus for efficient pasteurization, in which the milk is kept at a temperature of from 158° to 160° for thirty minutes, after which it is rapidly cooled. He gives the following results of the bacteriological examination of five samples, before and after pasteurization: No. 1, before pasteurization, had an average of 102,600 bacteria in every ten drops, but only two to three after the process was completed; No. 2 had 251,600 before and thirty to forty after; No. 3 had 25,000 before and three to five after; No. 4 had 37,500 before and two to five after; while No. 5 had 94,000 before and only two after. These figures have been confirmed by Freudenreich of Berne.

A very simple apparatus is sufficient for household use, the essential parts being: An easily cleansed bottle with a cotton wool plug, to contain the milk; a metal vessel provided with a wire stand at the bottom to support the bottle; and a thermometer, the stem of which passes through the lid of the outer vessel, so that the temperature can be ascertained without the cover being removed. The temperature of the water should be slowly raised to 160° F., after which the vessel should be taken off the fire, and should be kept for thirty minutes under a thick cozy. At the end of this period the bottle should be taken out of the water, and put in a cool place so that the temperature of the milk may be lowered as rapidly as possible.

A large number of special appliances have been invented for the sterilization of milk. They may be divided into two classes: Those that are arranged for dealing with the milk in bulk and those that are adapted for dealing with small quantities of it in bottles. As regards the former, the most effective and at the same time the most economical forms of apparatus are those in which the milk is treated with steam under pressure, the storage vessels being filled and closed in such a way as to make it impossible for any micro-organisms to get in during the process.

In the second type of sterilizer the milk is placed in feeding bottles, which are immersed, as in Soxhlet's apparatus, in water, or around which steam is passed, as in the apparatus used in the Walker-Gordon milk laboratory of Boston. The disadvantage of this method is, that the cream tends to rise and to adhere to the necks of the bottles, so that a certain proportion of it is left behind after the child has finished its meal.

The advantages of raw milk are the following: The fat contained in it is in a more perfectly emulsified condition, it is more pleasant to the taste, the free and combined carbonic acid (7·5 per cent. and 2·2 per cent. respectively) not having been driven off, the phosphorus and lime salts remain in their normal condition, and, finally, its casein is more digestible than that of milk which has been heated to 212° F. The great disadvantage of the use of raw milk in England is that with our present system of control and management of dairies, it is impossible to insure against the milk becoming contaminated with large numbers of micro-organisms, some of which may be pathogenic. If we had dairies, such as those of the Milk Supply Company of Copenhagen, and the Walker-Gordon milk laboratories of Boston, where direct and efficient control is exercised, it would be worth while to dwell upon the very marked advantages possessed by raw milk for the feeding of infants. In order to render its use safe, however, the cow must be treated with the same care and consideration as a human wet nurse.

Foul milk cannot be rendered wholesome by any amount of household boiling. It is very much easier to sterilize clean milk at a comparatively low temperature than milk which swarms with bacteria at a much higher one. Unfortunately, it is necessary for us to consider not only the best means of dealing with milk such as we have it, but with milk such as we get it. This in most cases is rich in bacteria.

Undoubtedly the chief advantage of sterilized milk is, that all the pathogenic, the majority of the non-pathogenic, and the adult forms of even those bacteria which have especially resistent spores, are thereby destroyed. In my opinion, this far outweighs any disadvantages there may be to the process. However, prepare cow's milk as we may, we cannot shut our eyes to the fact that it is out of the question to anticipate such good results in the majority of cases from artificial as from breast feeding. The fat of cow's milk is quite different in composition from that of human milk. Thus we see that human milk differs from cow's milk, not only in the percentage quantity of its ingredients, but also in the molecular composition of these ingredients; hence we must not blame the process of sterilization for defects which are inherent in the cow's milk itself.

Undoubtedly the chief objection to sterilized milk is that its casein is less digestible than that of unsterilized milk. In the artificial digestion of diluted milk rich in cream I found that the casein of the unsterilized milk was digested in about half the time required by the casein of the sterilized milk. Further, there is a difference in the action of rennet, the coagulum in the one case being quite different from that in the other. This is partly due to the precipitation of calcium salts, but not entirely, for if we add hydrochloric acid, and thus redissolve these salts, we find that the coagula are still different. This relative indigestibility of the casein of

* H. J. Campbell, M.D., in the British Medical Journal.

sterilized milk is of the greatest importance, for in most cases it renders it necessary that the intervals between the meals should be longer for infants fed upon sterilized than upon unsterilized milk. Indeed, where there is a certain amount of gastric atony, the infant may be unable to take a sufficient quantity of milk for the purpose of nourishment, and thus may undergo a process of slow starvation.

The experience of cases such as these has given rise to the belief that rickets, and especially scurvy rickets, may be induced by the use of sterilized milk. This is true, I believe, but the cause of these diseases is that the child has been receiving insufficient food, and especially an insufficiency of carbo-hydrates and fats, rather than that there is a "subtile change" in the milk as the result of sterilization. Randolph, of Philadelphia, conducted a series of experiments upon adults and found that the raw milk had in every case been digested more rapidly than the boiled.

A second, though less important objection, is the fact that the taste and smell of the milk are altered, and although this rarely matters in the case of young infants, it sometimes causes difficulty with older children.

Another disadvantage is that the greater part of the carbonic acid gas in the milk is driven off, thus inducing an alteration in the composition of the phosphates, and a precipitation of calcium and magnesium carbonates.

Fourthly, some of the fat globules coalesce, the result being that the emulsification is not quite so perfect as in raw milk.

Fifthly, the lact-albumen is coagulated and gives rise to the albuminous skin which forms upon the surface as the milk cools, even if it has not been boiled, and contains entangled in its meshes a considerable quantity of fat, thus rendering the milk correspondingly poor in this most important ingredient.

Sixthly, any leucocytes that may be present in the milk are killed during sterilization; however, as at present we know so little about the role of leucocytes in milk, we are unable to state whether this is a disadvantage or not.

On the following grounds pasteurized milk is to be preferred to sterilized milk:

First, the digestibility of the casein is only diminished to a slight extent.

Secondly, the taste and smell of the milk are not permanently altered.

Thirdly, less carbon dioxide is driven off.

Fourthly, the condition of the fat remains practically unchanged.

Fifthly, the lact-albumen is not coagulated.

Of late, great attention has been devoted to the subject of the adaptation of cow's milk to the needs of the human infant. I would like to draw attention to the excellent results which have been obtained by the use of Dr. Gaertner's fat milk in various parts of Austria and Germany. Dr. Pollak, in Vienna, writes me that its use has been attended with the best results in cases of rickets. Its mode of preparation is as follows: Dilute the milk with an equal quantity of sterile water in order to halve the amount of casein; centrifugalize the mixture at a temperature of 35° C., and allow the creamy portion of the milk to flow direct into a cooling chamber, where its temperature is reduced to 15° C. The fat milk so obtained contains only half the proteids and milk sugar, but all but 2 per cent. of the fat of the original milk. It is then sterilized in a Popp-Becker sterilizer at a temperature of 102° C., after which it is rapidly cooled down to a temperature of 18° C.; thirty-five grammes of milk sugar should be added to each liter of the fat milk.

Gaertner's fat milk appears to be as well adapted to the needs of infants as Frankland's humanized milk, while its mode of preparation is much simpler. For household purposes the method recommended by Dr. Ashby is both simple and effective. The fresh, clean milk is allowed to stand in the 30 oz. sterilized bottle of a pasteurizing apparatus for two hours, during which time the greater part of the cream rises to the surface; the lower half is then siphoned off and replaced by boiled water, in which an apothecary's ounce of milk sugar has been dissolved. In my opinion in most cases it is better to replace the milk, which has been siphoned off, by thin barley water. Experimentally, I have found that, when barley water is mixed with milk, the curd formed during artificial digestion is more granular than that formed in the mixture of milk and plain water. I have had the barley water of the consistency that I recommended analyzed; the total solid matters only amount to 1·23 per cent., being made up of 0·117 per cent. albuminoids, 1·078 starch dextrin, etc., and 0·035 per cent. of mineral matters. The small quantity of starch is of no great importance, especially when we take into account the fact recently pointed out by Heubner and Zweifel, namely, that the salivary glands of the infant are functional at a much earlier age than was previously thought. It is well, also, as Jacobi has suggested, to add a small quantity of common salt to the prepared milk, as there is less of this important food constituent in cow's than in human milk; in the former only 12·5 per cent. of the ash consists of chlorine, while in the latter the proportion is 20·11 per cent.

The plan adopted in the Walker-Gordon and other milk laboratories in America of modifying the milk according to the physician's prescription is one that might be followed with great advantage in certain cases.

Finally, I would like to point out that one source of great danger in the artificial feeding of infants is the idea so firmly rooted in the public mind that the strength of the milk given should be rapidly increased. Analyses of human milk at different periods of lactation show that its percentage composition does not vary to any great extent, the chief difference being in the quantity secreted. The percentage strength of the cow's milk should only be increased with the greatest caution.

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